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Author(s):
Manjula Guru: (918) 647 – 9123; manjula@kerrcenter.com (Presenter),
Eric Wailes: (501) 575 – 2278; ewailes@comp.uark.edu,
Gail Cramer: (501) 575 – 6935; gcramer@comp.uark.edu.

Manjula Guru is an Agricultural Economist,
The Kerr Center for Sustainable Agriculture, Inc.,
P. O. Box 588, Poteau, OK 74953.

Eric Wailes & Gail Cramer are Professors,
Department of Agricultural Economics & Agribusiness,
221, Agricultural Building, University of Arkansas
Fayetteville, AR 72701.
(501) 575 - 5306 (fax).

Title:
Impact of Pesticide Regulatory Policies on U.S. Rice Production.

Abstract:

This paper examines the costs and benefits of pesticide regulations on US rice production. Benefit - cost analysis of FIFRA (The Federal Insecticide, Fungicide, and Rodenticide Act) has been done taking into consideration the externality costs associated with the Endangered Species Act and the Worker Protection Standard, for which compliance under FIFRA has become mandatory since 1990.

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IMPACT OF PESTICIDE REGULATORY POLICIES ON U.S. RICE PRODUCTION.

Introduction:

Modern production practices of rice in the U.S. require fertilizers and pesticides. Grown under flooded irrigation, rice plant diseases and pests can have a devastating effect on yields without chemical controls (Knutson er al., 1990). To produce larger harvests with less labor input, chemical - intensive farming has been introduced. Rice producers have increased their use of pesticides in rice production; but more recently using more effective chemicals they have been able to decrease the quantity of active ingredients per acre. The chemical costs amount to 12 - 15 % of the total production cost of rice in the U.S (Setia et al., 1992).

Concern however for the environment has resulted in U.S. federal policies that regulate pesticide availability and use. In 1947 Congress responded to the situation by enacting the comprehensive Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) requiring that pesticides distributed through interstate commerce be registered with the United States Department of Agriculture (USDA). In 1970, the administration of FIFRA was passed to the newly created Environmental Protection Agency (EPA), whose regulation of pesticides is now mandated by Congress.

FIFRA, which has been amended in 1972,1975, 1978, 1980, 1988, 1990 and 1996 is a complex statute. A series of changes, were made to provide the EPA with authority to regulate pesticides to prevent unreasonable adverse effects on the environment. The application and authority of FIFRA can be challenged by several other regulations, most significantly, the Worker Protection Standard (WPS), and the Endangered Species Act (ESA). In 1990, the EPA issued final regulations governing the protection of employees on farms, forests, nurseries, and greenhouses from occupational exposures to agricultural pesticides in compliance with the WPS provisions. FIFRA is also required to ensure, in keeping with the ESA, that the registration of pesticides and their use are not likely to jeopardize endangered species.

This study analyses the economic impact of pesticide regulation on the U.S. rice industry. Most previous studies have examined the economic impact of complete or partial bans. This study contributes to the literature by examining the net economic welfare effects of the regulation on pesticide industry costs as they filter through a specific commodity market.

The Economic Effects of Pesticide Regulation:

The direct market effects of a government regulation often have an impact on a product's price, and on its production and consumption level. On the other hand, the indirect market effects include impacts on the product's substitutes and complements, inputs, and on further processed products. Pesticide regulation can be viewed as an implicit tax that drives a wedge between the price received by the pesticide user (the farmer), and the producer (chemical company). The pesticide suppliers would now pass on the FIFRA regulatory and research costs to the producers of rice who are also the consumers of pesticides, by increasing the pesticide prices. The direct response by the rice producers is a reduction in the pesticide use and planted rice acres.

With the increasing stringency of FIFRA regulations, the pesticide companies now put forth for registration only those pesticides which have been vigorously tested in the laboratory as well as in the field. These pesticides therefore are not only more expensive but also produce better results in the form of higher yield per acre. Also, the farmers who now have to make a choice on the number and quality of the planted acreage would rationally invest their resources in the more optimally productive acres. With the increase in pesticide costs per unit and a shift in the pesticide production, a decrease in pesticide supply is accompanied by higher pesticide prices and consequently higher rice production costs. The resulting shift in rice supply along the demand curve results in a new rice market equilibrium.

A second dimension of pesticide use, other than the market effects of regulation, are the non - market or external effects. The change in rice consumers' and producers' surplus, measures only the market effects. In evaluating the net social benefit of pesticides, it is necessary to consider also any nonmarket impacts such as effects on human health and the environment. While increasing the productivity of the land on which they are applied, pesticides can also have chronic health effects, be harmful to fish and wildlife, and can have other environmental or health consequences. Without government regulation, such nonmarket effects result in economic costs and benefits and their value would be not reflected in the rice market.

Conceptual Model:

The net welfare effects are estimated using the measures of changes in consumer and producer surplus in the rice market and the externality effects from reduced environmental damage due to regulation and the direct costs of regulation. This is expressed in the following equation.

- Net welfare effects = $\Delta CSt + \Delta PSt + NEB_t + Gov_t$., where

ΔCS_t = Change in consumer surplus on time period t; ΔPS_t = Change in producer surplus in time period t; NEB_t = Net externality benefits in time period t; and Gov_t. = Government costs of implementing regulatory policies over time period t.

Empirical Model:

To estimate the change in producer and consumer surplus with and without FIFRA, the market equilibrium prices and quantities with and without government intervention must be estimated. The actual prices and quantities observed with the regulation in effect are published by the Economic Research Service, U.S. Department of Agriculture (USDA). As discussed in these publications, 1.2% of the total U.S. agricultural pesticide usage is on rice. The producer and consumer surpluses with the regulation in effect, were then calculated for the published data. The equilibrium free market prices and quantities are estimated from the available data[1]. A 0.53 price elasticity of supply for rice, and a -0.48 price elasticity of demand for rice which have been estimated by Cramer et. al, are used for the purposes of this study.

To calculate the producer and consumer surplus without FIFRA, the pesticide costs, gross margin, rice acreage harvested, rice yields per acre, total annual rice production, and the rice price per unit without regulation have been estimated as follows (where * refers to estimates without FIFRA regulation):

[1] To estimate the regulation producer and consumer surplus, the regulation equilibrium price(P*) and equilibrium quantity (Q*), and the price elasticities of supply ($E_S = d(P^*/Q^*)$) and demand ($E_D = -b(P^*/Q^*)$) for U.S. rice were used. Using these equations for elasticity of supply and demand, the values for the parameters a, b, c, d were calculated as follows:

- $E_D = -b(P^*/Q^*) = -0.48 \geqslant b = -(-0.48{*}Q^*) \div P^* \geqslant a = Q^* + bP^*$

- Rice pesticide costs* = Pesticide costs/acre X rice acres - pesticide industry research and regulatory costs X 1.2%)
- U.S. Rice pesticide costs/acre* = Rice pesticide costs* ÷ rice acres.
- Gross margin/acre* = gross margin/acre - pesticide cost/acre + pesticide cost/acre*
- Rice acreage* = Rice acreage - (0.53 * % Δ in gross margin/acre)
- Rice yield/acre* = rice yield/acre X (1 - % Δ in rice yields/acre[2])
- Total rice production* (Q*) = rice acreage* X rice yields/acre*
- Rice price* = rice price - % Δ change in rice price[3]

Estimates of externality costs and benefits associated with any regulation is usually met with skepticism as there is no one fixed method for calculating them. This study estimates them as: Net externality benefits = FIFRA externality benefits - FIFRA externality costs.

- FIFRA externality benefits = endangered species benefits + WPS benefits.
- Endangered species benefits = number of delisted endangered species average value of the endangered species X 1.2% X 75%.[4]
- Worker Protection Standard benefits = ([average number of rice pesticide worker deaths for 1989-90 - number of rice pesticide worker deaths in that year] X 1.2% X average value of a human life[5]) - rice WPS compliance.

- $E_S = d(P^*/Q^*) = 0.53$ ⋗ $d = (0.53 \cdot Q^*) \div P^*$ ⋗ $c = Q^* - dP^*$

The intercepts (a/b) and (c/d) were then determined using the calculated parameters.

[2] Elasticity of yield with respect to acreage (N_{ya}) = -0.15, therefore % Change in rice yields/acre = -0.15 X % Change in rice acreage. (Cramer et al.)

[3] % Change in rice price = % Change in rice production ÷ -0.48

[4] As per the U.S. Fish and Wildlife Services Division of the Endangered Species, the average value that is placed on an endangered species life can be estimated approximately to be U.S. $2.6 million (U.S. 1995 $s) and 75% of the threat posed to endangered species is because of pesticide usage.

- FIFRA externality costs = appropriated rice acre loss + WPS compliance costs + endangered species costs.[6]
- Loss to society because of appropriated rice acres = number of appropriated acres X 1.2% X average annual net revenue of rice per acre.[7]
- Endangered species costs = number of endangered species declared extinct X average value of species X 1.2% X 75%.

The 1990 FIFRA amendment makes it mandatory for FIFRA to comply with the endangered species provisions and the worker protection standard provisions. While the government costs for the Worker Protection Standard Compliance Costs are part of the total FIFRA government costs allocated to the EPA, the U.S. Department of Interior is annually allocated funds for the enforcement of the Endangered Species Act.

- 1972-90 government costs = (total EPA budget by U.S. government X 13.3% X 1.2%)[8]
- 1991 - 95 government costs = (total EPA budget by U.S. government X 13.3% X 1.2%) + (total USDI budget by U.S. government X 2.6% X 1.2%)[9].

<u>Results:</u>

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[5] The average value placed on a human life, which as per the Warsaw Convention is stated to be $75,000, is assumed as a baseline value and alternative assumption on this value are analyzed.

[6] All data has been taken from USDA publications and from its website.

[7] Lands on which the endangered species are spotted are appropriated by the government, and listed as protected lands. While the owners of these lands are compensated (by the budget for the ES Protection Costs), the appropriation would nonetheless qualify as a social cost, because had these lands not been appropriated they would in all probability have been cultivated. [http://www.fws.gov/r9endspp/lists.html].

[8] 13.3% of all EPA budgets are allotted for the regulation of pesticide programs. It has therefore been assumed for purposes of this study that these funds are intended as FIFRA regulation costs. FIFRA government costs for rice for each of the years 1973 - 90 have been calculated to be (13.3% * 1.2%) of the total funds allocated to EPA by the United States government for that year.

[9] 2.6% of the total U.S. Department of Interior (USDI) expenditures are allocated for the endangered species program, and 1.2% of the 2.6% funds are applicable with regard to rice.

The results arrived at by following the model discussed above, showed that with FIFRA, average pesticide cost per acre and total U.S. rice pesticide costs are increasing.

Table 1: Net welfare effect with FIFRA, and efficiency costs of achieving externality benefits, 1973-95.

Year	Change in producer surplus	Change in consumer surplus	Net externality benefits	FIFRA government costs	Net welfare effect	Efficiency costs of achieving external benefits[10]
	(mil.'95 $s)	(mil.'95 $)	(mil. '95 $)	(mil.'95 $s)	(mil.'95 $)	(mil.'95 $).
1973	-0.055	-1.281	Na	-4.081	-5.412	Na
1974	-0.054	-1.334	Na	-8.007	-9.392	Na
1975	-0.084	-2.307	Na	-9.155	-11.538	Na
1976	-0.106	-3.181	Na	-10.956	-14.220	Na
1977	-0.089	-2.329	Na	-14.957	-17.356	Na
1978	-0.076	-2.114	Na	-12.646	-14.827	Na
1979	-0.053	-1.339	Na	-13.277	-14.665	Na
1980	-0.048	-1.137	Na	-13.587	-14.771	Na
1981	-0.048	-1.286	Na	-11.188	-12.517	Na
1982	-0.047	-1.298	Na	-10.281	-11.621	Na
1983	-0.061	-1.640	Na	-7.976	-9.670	Na
1984	-0.039	-1.093	Na	-6.838	-7.966	Na
1985	-0.038	-1.169	Na	-7.227	-8.428	Na
1986	-0.011	-0.573	Na	-7.588	-8.170	Na
1987	-0.044	-1.164	Na	-6.961	-8.163	Na
1988	-0.029	-0.659	Na	-5.952	-6.638	Na
1989	-0.039	-1.192	Na	-5.486	-6.710	Na
1990	-0.032	-0.955	Na	-5.348	-6.330	Na
1991	-0.057	-1.618	-0.403	-5.687	-7.757	85.189
1992	-0.017	-0.561	-0.048	-5.475	-6.099	25.289
1993	-0.043	-1.218	-0.014	-5.005	-6.273	23.408
1994	-0.022	-0.685	-0.042	-4.642	-5.389	18.110
1995	-0.077	-2.033	0.058	-4.876	-6.910	20.729

Na = Not Available.

With FIFRA, the gross margins per acre and the total U.S. rice acres are slightly less; U.S. rice yields per acre are slightly higher and total U.S. rice production is lower;

and U.S. rice prices per unit are higher. With the 1990 FIFRA Amendment, producer and consumer surpluses for rice have decreased. FIFRA externality benefits have gradually increased and FIFRA externality costs have decreased over the years 1991-95. The government has had to incur additional expenditures with FIFRA. However, over the period 1991-95, the government costs of implementing FIFRA are becoming lower. The net externality benefits of FIFRA are gradually becoming positive, and efficiency costs of achieving externality benefits are decreasing. Net welfare effects although negative are trending towards zero or positive values.

The efficiency costs of achieving externality benefits per dollar spent, have been decreasing over the years 1991-95, from $85.189 million in 1991 to $20.729 million in 1995. This means that even though the net welfare effects continue to be negative and do not indicate any gain to society from FIFRA, society now incurs less expenditure to achieve externality benefits (Table 1).

Table 2: Net welfare effect with FIFRA, and efficiency costs of achieving externality benefits, 1991-95, if a value of $5 million is placed on a human life.

Year	Change in producer surplus	Change in consumer surplus	Net externality benefits	FIFRA government costs.	Net welfare effect	Efficiency costs of achieving externality benefits
	(mil.'95 $s)	(mil.'95 $)	(mil. '95 $)	(mil.'95 $s)	(mil.'95 $)	(mil. '95 $).
1991	-0.057	-1.618	19.053	-5.687	11.699	0.330
1992	-0.017	-0.561	20.117	-5.475	14.066	0.251
1993	-0.043	-1.218	20.052	-5.005	13.793	0.284
1994	-0.022	-0.685	20.026	-4.642	14.679	0.239
1995	-0.077	-2.033	19.339	-4.876	12.371	0.369

Results of a sensitivity analysis done by placing an average value of $5 million dollars, as suggested by Crutchfield et al. in their study, instead of $75,000 on a human life

[10] Efficiency costs of achieving external benefits = (Change in consume surplus + change in producer

were completely different from those in Table 1[11]. In the second case the net externality benefit values completely dominated the net welfare effect values. The efficiency costs of achieving externality benefits fluctuated over the period 1991-95 (Table 2), and were very small when compared to the values shown in Table 1.

Limitations of this Study:

This study encounters serious data limitations. The data available on pesticide use on rice is inadequate to conduct a totally accurate benefit - costs analysis. USDA field studies on the quantity of pesticides applied on rice, total rice acres treated, total number of pesticide applications per acre, and the quantity of pesticides applied per application is conducted once every four to six years, rather than every year as in the case with corn, wheat, sorghum, etc. There is also a serious inadequacy of the data available on the effects of pesticides on the endangered species. No studies have been conducted (and if conducted are not reported), to find out what percentage of the threat posed to the endangered species is because of pesticides for the years 1991-95. It is important that more field studies be conducted on the endangered species by the concerned agency. It should also be noted that the data available on the monetary costs and benefits to farm workers, including morbidity losses because of pesticide usage, is not adequate to properly assess the impact of environmental regulations. The benefits of the Worker Protection Standard Compliance Costs need to be explored by the Office of Pesticide Use.

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surplus + FIFRA externality costs + FIFRA government costs) + FIFRA externality benefits.

[11] There is no universally accepted method to estimate the value of a life (Cropper and Oates, 1992; Hayes et al., 1995; Randall, 1993; Smith, 1992; Viscusi, 1992). Four dimensions in valuing life are the duration of life, future versus present life, life in terms of social or economic productivity, and the relation of efficiency (cost - effectiveness) to equity. Crutchfield et al. (1997), in their study assigned values between $15,000 to $1,979,000 (1995 $), depending on age. Vascusi (1993) has assigned a $3.6 to $8.4 million (1995 $) to a life.

Another limitation of this study is the probability that FIFRA's effects on the U.S. rice industry may have been underestimated. The rice pesticide data in this study are not fully accurate because of to the inadequacy of actual published data. Values for pesticide usage and application on rice for the years 1991-95 were computed with the assumption that 1.2% of the total agricultural pesticide application was on rice. This percentage was derived by taking the average of the various rice pesticide usage values published by the USDA - ERS. It is possible that the threat to the endangered species attributed to the pesticide applications on rice may be underestimated. This is so because of the lack of reliable data, as was discussed above, values had to be estimated for purpose of this study. The percentage of the threat posed to the endangered species attributed pesticides in this study, which is 75%, was unofficially estimated based on conversations with an official in the Office of Environmental Contaminants, Fish and Wildlife Division.

The benefits of the WPS on agricultural workers has been estimated for purposes of this study by placing a monetary value of $75,000 on a human life. The benefits may be different if monetary values were assigned taking into consideration the age, occupation, number of dependents, etc., of the workers affected. Also, the possibility is high that the values estimated for efficiency costs of achieving externality benefits may be incorrect, because the FIFRA externality benefit values are based on assumptions.

It should be noted that it is a major assumption of this study that the pesticide industry is a perfectly competitive market. The results of this study would not apply in a monopolist's market. In that case, the passage of FIFRA would increase the price of pesticides considerably more because the pesticide industry would not be willing to suffer a loss of producer surplus in any circumstances. The pesticide producer would elect to not only cut down the production of pesticides, but also to increase their prices. This would then result in per unit rice prices considerably higher than is the case in a perfectly competitive market. The regulation may in such a case drive the economy further from the point of social optimality than if the distortions were allowed to offset each other.

Implications of this Study:

This study makes a significant contribution to the literature on the costs and benefits of pesticide regulation. Unlike much of the previous literature which is premised on the extreme regulatory assumption of a complete ban on pesticides, this study assesses actual pesticide regulation compared to no regulation. FIFRA regulations on the pesticide industry is analyzed by assessing the impact of the regulatory costs on the pesticide costs to rice farmers, reduced rice output and higher prices on consumers and reduced externality damages. While the methodology used for this study is the widely accepted economic welfare framework, its application to the regulation of pesticides provides useful insights about the impact of regulation on the pesticide industry, rice farmers and consumers, and the environment. This study also brings into focus the lack of, the absolute need for adequate data to conduct a benefit - cost analysis of this kind.

Conclusions:

The net welfare effect of FIFRA regulation on pesticides used on U.S. rice production is gradually becoming less negative over the years. The net benefits, which were taken into consideration for the period 1991-95 have become less negative, and became positive for the year 1995. The decrease in the efficiency costs of achieving externality costs per dollar further prove that FIFRA externality benefits are increasing when compared to the total FIFRA costs. Net welfare results were positive if the value placed on a human life was taken to be $5 million instead of $75,000, and the efficiency costs of achieving externality costs per dollar supported the view that the externality benefits of FIFRA are greater than the costs incurred.

In making the assessment of a negative net social welfare impact, many assumptions are made. Perhaps the most important is the assumption that society places equal weights on all the estimates of costs and benefits. Clearly society in implementing policy, such as polluter pays, assigning property rights, places both explicit and implicit weights on costs or benefits. The distribution of property rights matters to society (Schmid, 1987). Therefore, positive net values could result if the externality benefits are more heavily weighted than the government costs, and producer and consumer losses.

In the absence of FIFRA, U.S. rice production and U.S. rice exports too would have increased[12] along with a decrease in U.S. rice imports[13] (Chavez, Wailes and Cramer, 1998). However, with an increase in the supply of U.S. rice in the world market, world rice prices decline, and thus the demand for U.S. rice increases.[14] It can also be concluded with the results derived from an analysis of the data that, (1) data available is not adequate to cover all questions that need to be answered in a benefit - cost analysis of this kind, and (2) data available cannot be said to be completely correct and reliable to be the basis of important decisions by the EPA, that involve human health, crop production and ecological safety that the Agency is regularly faced with and has to make.

In conclusion, it can be said that the pesticide effects are now not as harsh and environmentally unfriendly as they were prior to the passage and strict enforcement of

[12] As per the Arkansas Global Rice Model, the U.S. export supply elasticity with respect to the change in U.S. rice production is 1.001.
[13] The import demand elasticity for rice is -0.110, as per the Arkansas Global Rice Model.

FIFRA. FIFRA's stringent provisions made it a necessity for the pesticide companies to conduct vigorous tests on the pesticides before they are introduced into the market for use. The pesticide industry appears to be internalizing the externality costs, and then passing on these costs to society in the form of higher pesticide costs. While FIFRA is estimated to have resulted in a negative net welfare impact for society, the need for and relevance of FIFRA cannot be disputed. FIFRA has introduced the requirement for pesticide registrations, and has made it mandatory for pesticide companies to thoroughly test their products before making them available for the public. Its benefits, reported as well as those not reported, are considerable and justify the continuation of this regulation.

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[14] The World Demand Elasticity for U.S. rice, according to the Rice Model is -1.123.