Agrichemical Reduction Policy: Its Effect on Income and Income Distribution

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Abstract. *When farm chemical use is restricted, gross farm income rises, but net income may fall A 10-sector applied general equilibrium model was used to arrive at this assessment Compared are a chemical use tax, an input restriction on chemicals, and a farm sales restriction imposed on input suppliers The tax and sales restrictions reduce net income because of rising costs, while the input restriction holds the potential for raising net farm income*

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Whether or not clean water and food safety have been compromised by misuse or overuse of farm chemicals, the environmental impact of farm input use is now a public policy issue Several studies have attempted to capture the effect of complete bans on certain chemicals on particular crops (see, for example, *10* and *11*), but any across-the-board restriction is likely to have economywide consequences [1] Across-the-board restrictions would mandate reduced use of all chemicals rather than targeting individual chemicals for complete removal Current regulations do not impose sweeping bans or even partial reductions in agrichemical use, but such proposals have been broached

Approaches to chemical regulation are becoming more creative At least 37 States have their own, often varied, laws regulating, for example, water quality State policies range from taxing fertilizer to regulating practices and quantities of chemical use (*14*). Some reformers have advocated steep reductions in chemical use across the country, for example, a 50-percent reduction in chemical use (*12*) Some proposed national legislation tends to be more sweeping than past approaches [2]

The economic consequences of a general reduction in chemical use, as opposed to a one-at-a-time, chemical-by-chemical reduction have not been thoroughly studied A recent study (*8*) concluded that its exhaustive look at a complete chemical ban from agriculture was only a "first step" toward assessing the impact of the more likely imposition of partial reductions

The purpose of this article is to determine the effects of an across-the-board reduction in chemical use, demonstrating how economic rents and burdens may be generated and distributed, and presenting policy alternatives that could change the distribution of these rents and burdens In this study, "chemicals" refers to nitrogen and phosphorus fertilizers as well as pesticides Although a complete model gives industry-by-industry price and quantity changes brought about by the reduction, I present these results only to provide a baseline from which to evaluate income and welfare changes

The Model

Because the consequences of a sweeping agrichemical reduction will have consequences beyond the farm sectors directly affected, I used a computable general equilibrium (CGE) model Hertel (*6*) summarizes the strengths of CGE analysis (for the case of a farm subsidy) with four general points

- The CGE model explicitly acknowledges the finite resource base of the economy
- The question of who foots the bill for the subsidy (or other distortion) cannot be sidestepped in a fully specified CGE model
- The consumer's budget constraint, linking factor returns and uses of income, is modeled directly
- There is a definitive check on the conceptual and computational consistency of the model

In this analysis, a distortion, in the form of a quantity restriction on chemical use in agriculture, is placed in the producing sectors between the manufacturers and users of chemicals The producing sectors are linked—laterally to one another through interindustry flows, backward to the resource base (owned by consumers), and forward to consumers by final demand A straightforward approach traces down who really "foots the bill" for the distortion The "conceptual check" on the consistency of the model also proved to be important, since rents generated by a partial ban—often overlooked in other analyses—must be received by someone

The model employed includes 10 individual producing sectors, each making a single homogeneous product The agricultural sector is disaggregated into three subsectors a) feed grains and oilseeds b) poultry, dairy, and livestock, and c) other agricultural products, including fruits and vegetables Nonagricultural sectors are a) manufacturing, b) services, c) livestock processing, d) feed grain and oilseed processing, e)

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article

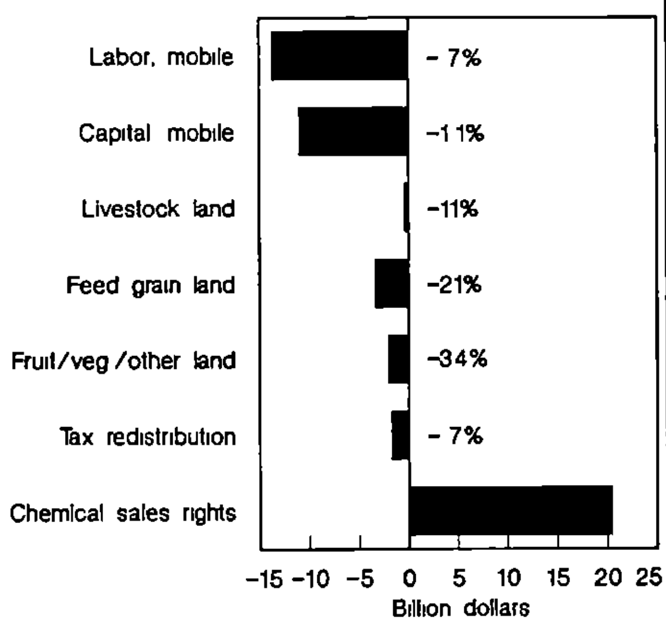
[2]Recent Senate and House versions of a bill establish tougher, so-called "negligible risk," standards for pesticide approval, permitting the Environmental Protection Agency to charge fees for its regulatory work

how the reduction policy is implemented Measuring this change determines the distributional effects of the restriction To determine how a particular agent will fare, we must know what part of each asset the agent holds Asset values tend to decline when they are in an industry that is an intensive user of agricultural chemicals and when they cannot be transferred out of that industry The land rental rate, as an example of returns to a nonmobile resource, is determined by its derived demand and its availability Removing one input usually lowers the value of the marginal product (VMP) of the others due to the complementarity of inputs Thus, chemical reduction lowers the VMP of land in agriculture through the lower marginal physical product (MPP, the change in the physical output component of VMP), and reduces returns The drop in the rental rate is moderated, but in this case not overcome, by rising agricultural prices, the other component of VMP For a factor like labor, this drop in returns is tempered by mobility, and labor moves out of agriculture

The 75-percent chemical restriction most influences returns to factors dedicated to agriculture, mostly land (fig 2) The absolute level of returns declines more for the mobile factors, but the percentage drop, and thus the impact felt, is far greater for owners of land and agriculture-only factors of production

As the use of chemicals is restricted, the dwindling amount of chemicals becomes more valuable per unit of production This results in a difference between the cost of producing chemical inputs and their value in production In addition to physical factors of production, marketing rights begin to acquire value, having the potential (for a restriction level somewhere short of complete) to more than offset lost farm income as represented by returns to land. Whether these rents go to farmers or others is largely a matter of public policy

Figure 2
Change in asset values with a 75-percent restriction in farm chemical use



A number of policy options can reduce the use of chemicals in agriculture. Assuming that a policy aimed at chemical inputs is chosen, the likely instruments would be a tax on chemicals or a mandated reduction in chemical use, called a quantity restriction for simplicity Either policy introduces a wedge between supply and demand that could reduce input use to a targeted level

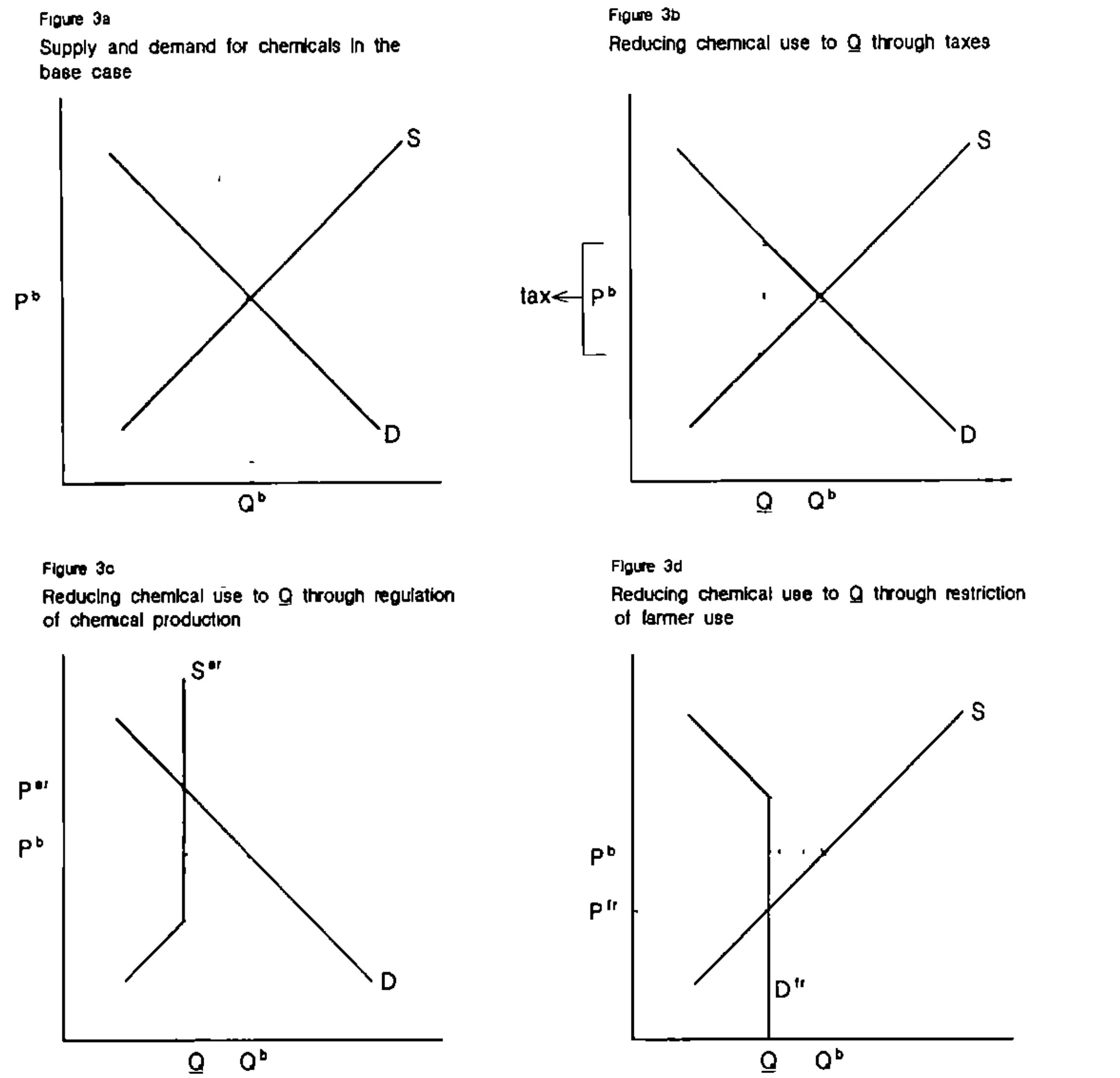
To understand the economic rent distribution, it is helpful to abstract from the general equilibrium effects Figure 3 illustrates, in a partial equilibrium setting, how a policy goal of chemical reduction could be achieved through a use tax, a restriction on farmer input use, or a quantity restriction on chemical manufacturers' output

In the unrestricted case (fig 3a), supply and demand converge at price P^b and result in quantity Q^b being sold and used If, from a public policy point of view, the appropriate quantity to be used is $\underline{Q}$, then several options are available (Though the diagrams in figure 3 appear much smaller, a 75-percent restriction is used in the general equilibrium examples which follow, unless otherwise noted) The tax in figure 3b simultaneously drives up the price farmers must pay and drives down the price suppliers receive (relative burdens being determined by elasticities) Although the general equilibrium effects make the model results more complicated than reflected in the diagram, the size of this transfer is estimated to rise to $20 billion by the time 75 percent of the chemicals now used are withdrawn from the market

Figure 3c assumes that, whatever policy is implemented, chemical producers can behave as monopolists Call this a "seller restriction " Suppliers are allowed to cut back their output to $\underline{Q}$ and extract the resulting rents from farmers Price, $\overline{P}^{sr}$, is then determined by demand Though this extreme outcome (the entire $20 billion going to chemical producers) is unlikely, it serves to establish one end of the welfare spectrum brought about by chemical policy This seller restriction would tend to benefit chemical companies if they had exclusive marketing rights over chemicals remaining on the market, and if inventory stockpiles were not a problem, and if no close substitutes were developed rapidly In this situation, most of the burden falls on farmers Chemical producers would be better off since the price rises due to the restriction are greater than the losses from reduced sales

Figure 3

Reducing farm chemical use by 75 percent: Effects depend upon mechanism used

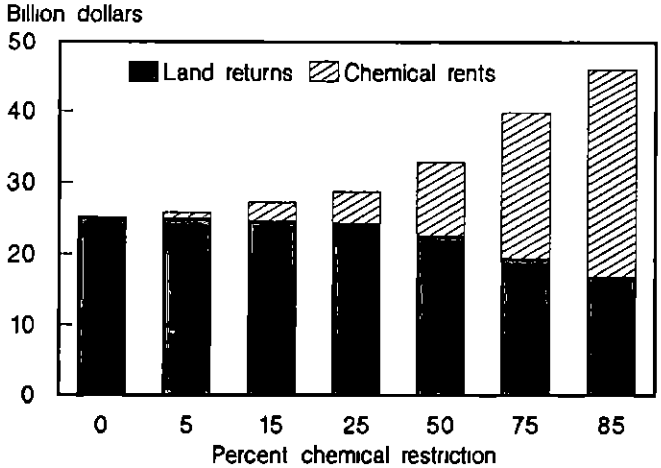


This figure is not to scale and does not include the shifting of supply and demand that takes place with the changes. Except for the distributional issue taxes, and quantity restrictions are assumed to have the same effect. Quantity restrictions and taxes are used to reduce chemical use to Q.

Figure 3d shows farmers who are able to cut back on chemical use and behave as monopsonists The demand curve becomes perfectly inelastic at Q and the price burden falls on the chemical producers This "buyer quota" scenario occurs only in the unlikely event that chemical manufacturers do not reduce supply in the face of these restrictions, a feasible case if farmers are permitted to cut back on particular chemicals to reduce overall use, or if manufacturers' stocks were burdensome The gain of $20 billion, if it went to farmers would more than offset the $5 billion lost by diminished asset returns If monopsony rents accrued to farmowners, total returns would rise despite the drop in returns to land services Figures 3c and 3d represent bounds on farmer and chemical producer burdens, respectively The likely actual outcome will depend upon the relative strength of the factors favoring farmers or chemical manufacturers

Figure 4 shows the change in total revenues to land and "marketing rights" and the change in composition As the restriction increases (moving to the right on the horizontal axis) returns to land services (measured in billions of 1982 dollars on the vertical axis) fall, but, if purchasing rights are the property of farmers, overall returns rise Researchers may reach different conclusions about farm income effects even with otherwise similar models and assumptions, if their ideas about chemical rents differ

Figure 4
Potential revenue changes for land and chemicals with varying levels of chemical restriction



Dynamic Effects[7]

Assuming that the distributional differences between a quantity restriction and a tax can be compensated, other considerations can cause the equivalence to break down. For example, exogenous shifts in supply or demand will result in different incidence patterns between the quantity restriction and the tax. Though the supply of chemicals is likely to be quite stable from one period to the next, shifts in derived agricultural demand, due to weather patterns or other considerations, are likely. In general, policies that lower farm input prices also bring greater price variability.[8] Chemical restriction policy then has the potential to affect not only prices but price variability. Price variability is policy dependent, and where variability is increased, welfare most likely falls for both producers and consumers (*7*).

Incentives and Product Development

In the past, chemicals have been restricted on a case-by-case basis, allowing the use of substitutes as the targeted chemical was phased out. Economic studies have predicted moderate impacts from bans of this type (*10, 11*) because many pesticides have one or more close substitutes. This approach to restriction also encourages a search, through research and development, for more acceptable substitutes. The current study approaches the problem under the assumption that all chemicals will be reduced across the board. This produces large aggregate effects, more than $13 billion lost to the domestic economy and up to $53 billion redistributed at the 75-percent restriction level alone. The aggregate effects occur because farmers, although able to substitute fairly easily away from particular chemicals, are not able to substitute as easily for chemicals as a group. This implies a small elasticity of substitution between chemicals and other inputs. In the long run, this elasticity would be larger and the price and output effects would diminish. Also, a more drastic across-the-board cut could halt the development of new chemical products regardless of their merit. Though properly handled in a dynamic model, the matter of incentive to develop safer products differs between an across-the-board chemical reduction and a case-by-case risk, or hazard-based criterion reduction. Development of new, more environmentally benign chemicals, like those developed for cotton after the banning of DDT, might actually be increased under the latter type of restriction since there would still be a market for chemicals that meet the necessary criteria. Of course, no incentive would exist for this development in the case of a total chemical ban. On the other hand, the development of nonchemical technology might be speeded up. Genetic engineering may introduce such revolutionary changes as corn plants with the ability to fix atmospheric nitrogen (like legumes), thus making the application of nitrogen fertilizers less necessary. Other genetic engineering possibilities include inducing vegetable plants to produce bacillus thuringiensis toxins (*4*), negating the need for many insecticides. Each of these pest or fertilizer developments carries its own type of risk, which must be considered.

Conclusion

How the economic burden of chemical reduction will be divided depends on the type of reduction policy enacted. The loss of production efficiency caused by the chemical reduction will be borne by society regardless of how the policy is implemented. This loss becomes disproportionately larger as the restriction is made more severe, maybe as high as $25 billion. The principle of equating marginal cost to marginal benefit provides a rule for determining how large to make the overall cutback in chemical use. The distributional effects, caused by the shifting value of factors of production in the economy and the possible creation of new monopoly rights, are determined almost entirely by the choice of policy instruments—whether the Government collects the rents generated or whether it allows chemical companies to behave as monopolists or farmers to behave as monopsonists. In the latter case, monopsony rents are expected to more than offset lost factor returns. The choice of policy instruments ultimately depends on what redistribution of wealth society finds preferable.

Though the CGE model does not directly deal with other time-related effects of chemicals reduction policy

[7]Dynamic as used here means simply any changes through time.

[8]This possibility has been noted in the trade literature comparing import tariffs and quotas. Analysis available from the author demonstrates these results using a simplified version of such work by Bale and Lutz (*1*).

that might be expected, analysts should consider them Variability of prices for chemicals (and thus farm products) can be affected by the type of policy employed Policies that lower farm input prices tend to bring greater price variability The incentive to develop more environmentally benign chemicals may be inhibited by a total ban but possibly encouraged by more mild restrictions

References

1 Bale, Malcolm D , and Ernst Lutz "The Effects of Trade Intervention on International Price Instability," *American Journal of Agricultural Economics* Vol 61, 1979, pp 512-16

2 Baumol, William J , and Wallace E Oates *Economics, Environmental Policy, and the Quality of Life* Englewood Cliffs, NJ Prentice-Hall, 1979

3 Boyd, Roy *An Econometric Model of Direct and Indirect Effects of Tax Reform on Agriculture* TB-1743 U S Dept Agr , Econ. Res Serv , Feb 1988

4 Gladwell, Malcolm "The Mysteries of Bt," *Washington Post* Nov 27, 1989, p A3

5 Harberger, Arnold C "The Incidence of the Corporation Income Tax," *Journal of Political Economy* Vol 70, No 3, pp 215-40

6 Hertel, Thomas W "General Equilibrium Analysis of U S Agriculture What Does It Contribute?," *The Journal of Agricultural Economics Research* Vol 42, No 3, Summer 1990

7 Just, Richard E , Darrell L Hueth, and Andrew Schmitz *Applied Welfare Economics and Public Policy* Englewood Cliffs, NJ Prentice-Hall, 1982

8 Knutson, Ronald D , C Robert Taylor, John B Penson, and Edward G Smith *Economic Impacts of Reduced Chemical Use* Knutson and Associates, 1990

9 McKinzie, G W , and I F Pearce "Welfare Measurement—A Synthesis," *American Economic Review* Vol 72, 1982, pp 669-82

10 Osteen, Craig, and Fred Kuchler "Pesticide Regulatory Decisions Production Efficiency, Equity, and Interdependence," *Agribusiness* Vol 3, No 3, 1987, pp 307-22

11 Osteen, Craig, and Fred Kuchler *Potential Bans of Corn and Soybean Pesticides Economic Implications for Farmers and Consumers* AER-546 U S Dept Agr , Econ Res Serv , Apr 1986

12 Pimentel, D , L McLaughlin, A Zepp, B Lakitan, T Kraus, P Kleinman, F Vancini, J Roach, E Grapp, W Keeton, and G Selig "Environmental and Economic Impacts of Reducing U S Agricultural Pesticide Use," *Handbook of Pest Management in Agriculture* 2nd ed D Pimentel (ed) Boca Raton, FL CRC Press, 1989

13 Rendleman, Charles M "The Economy-Wide Impact of the U S Sugar Program " Ph D dissertation. Purdue University, West Lafayette, IN, Aug 1989

14 Reichelderfer, K , and Tim Phipps *Agricultural Policy and Environmental Quality* National Center for Food and Agricultural Policy and Resources For the Future, Washington, DC, Nov 1988

15 Rutherford, Thomas F *General Equilibrium Modeling with MPS/GE* University of Western Ontario, London, Ontario, Canada, July 1988

16 Sakai, Y "Substitution and Expansion Effects in Production Theory The Case of Joint Production," *Journal of Economic Theory* Vol 9, 1974, pp 255-74