ESTIMATING COST OF BANNING AGRICULTURAL CHEMICALS:

THE CASE OF MANEB AND MANEB ALTERNATIVES

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INTRODUCTION

In recent years the health risks associated with the use of pesticides in agriculture has spurred the government to review the safety of many commonly used chemicals. This study focuses on the economic impacts of prohibiting the domestic use of one of these chemicals, maneb, which is an ethylenebisdithiocarbamate (EBDC) fungicide that is applied to 23 crops sold in fresh and/or in processed form worth an estimated 9.6 billion dollars at the farm level.[1] The study was undertaken in response to an Environmental Protection Agency (EPA) special review of the entire class of fungicides.[2]

Several aspects of the study distinguish it from those done previously. First, the impacts are estimated using a general equilibrium model that traces the supply effects of maneb into both farm and retail level prices. For the most part earlier pesticide regulation studies were either constructed in a partial equilibrium framework (Lichtenberg et al. 1988, Taylor and Frohberg 1977), or relied on partial budgeting (NRC 1980). One exception is the general equilibrium model, AGSIM (Taylor 1989). Second, the model calculates an approximately unique willingness to pay measure of consumer welfare changes using the Vartia (1983) algorithm. Previous studies, including AGSIM, calculated consumer welfare changes using ordinary rather than compensated

demand curves which have well-known path dependency problems (Silberberg, 1972).

Third, the model examines effects on prices, quantities, and welfare in vertically related markets that occur with substitution (Just et al. 1982). The welfare impacts in these related markets are calculated separately following the approach developed by Just and Hueth (1979). Although the AGSIM model also calculates some downstream welfare impacts, the effects in intermediate processor and distributor markets are not separated. Fourth, previous studies estimated the economic impacts of prohibiting the use of particular pesticides on individual major cash crops such as cotton. This is the first study that examines the impacts of pesticide restrictions applied to a large group of fruits and vegetables with interdependence in demand.

In addition, the economic impacts of banning maneb are calculated for producers of crops that do not use maneb but are significantly affected by changes in the prices of maneb-using crops. These crops are included in 15 crop groups defined by available demand elasticity estimates. Lastly, the effects on production and producer welfare for the 29 crops are disaggregated by production region to capture the distributional effects which occur due to the variability in growing conditions, cultural practices, degree of dependence on maneb, and the availability of alternatives among production regions. Maneb is used in all of the production regions for 11 crops and in at least half of the regions for 15 crops. Some regions are highly dependent on maneb while others use no maneb at all.

The percentage of the planted acreage to which maneb is applied varies between 3 and 65 percent depending on the crop and region. Approximately 50 percent of the bell pepper and spinach acreage is treated with maneb for which there is no viable alternative (Buhn 1987). Thus, the suspension of maneb could significantly reduce production of a particular crop in one region of the country while a relatively small effect may be observed in other regions.[3] Table I gives the average planted acreage, total farm value, and the percentage of acreage treated with maneb over the period 1984-86 for the 29 important maneb-using crops. The final column gives the estimated yield losses for each crop assuming that no maneb or maneb alternatives are available.

The benefits of maneb were examined under two scenarios. The first scenario considered the case where maneb is suspended and no other EBDC's currently under review can be used in place of maneb.[4] The second scenario considered the case where maneb is suspended and no other EBDC's nor Bravo, which is the main alternative to EBDC fungicides, can be used as substitutes.[5] The first scenario takes on greater significance since Bravo may also come under special review and because it frequently can not be used due to plant back restrictions (Buhn 1987). In each scenario, the annual welfare effects for producers, consumers, processors and producers of crops that do not use maneb were calculated for three different time horizons: one year, two years, and five years. This was done since the econometric estimates of supply are dynamic and allow for increasing adjustment over time as more investment and substitution in supply is possible.

The results of the model indicate that eliminating maneb has relatively mild effects when alternative fungicides are available. In contrast, when alternatives (Bravo) are not available the resulting welfare effects for many of the crops are substantial. Aggregate producer welfare for most of the crops increases substantially when no alternatives are available although the

Table I

Average Acreage Planted, Total Farm Value, Acreage Treated With Maneb, and Yield Loss Assuming No Maneb Alternatives Between 1984-86.

Crop	Acreage Planted (1000 Acres)	Total Farm Value (Million $)	Acreage Treated With Maneb (Percent)	Yield Lost[a] Assuming No Maneb Alter. (Percent)
Apples, Fresh	245	760	6.9	50
Apples, Processed	192	194	6.9	50
Beans, Dry	1,584	413	5.9	26
Beans, Snap-Fresh	88	91	38.4	40
Beans, Snap-Process	221	110	38.4	40
Broccoli	113	239	48.9	12
Brussels Sprouts	45	13	4.9	12
Cabbage	101	206	59.4	30
Cantaloupe	128	230	5.2	39
Carrots, Fresh	71	206	11.5	34
Carrots, Processed	24	24	13.6	34
Cauliflower	60	179	65.1	12
Celery	36	210	16.8	35
Corn, Sweet-Fresh	206	204	14.8	57
Cucumber, Fresh	47	84	6.4	31
Cucumbers, Proc.	112	111	4.0	31
Grapes, Fresh	108	281	19.5	15
Grapes, Processed	666	757	19.3	15
Honeydew	26	61	4.9	29
Lettuce	229	694	57.0	18.5
Onions	132	462	20.3	28
Peppers, Sweet	78	268	47.9	22
Potatoes, Fresh	523	713	29.4	23
Potatoes, Proc.	810	1,103	29.4	23
Spinach	35	72	47.2	48
Squash	64	132	8.5	31
Sugar Beets	1,160	789	3.1	16
Tomatoes, Fresh	130	744	20.7	29
Watermelon	231	219	11.7	26
Total	7,465	9,569	17.10	25.00

[a] Yield loss only refers to the acreage actually treated with maneb.
Source: Just, R.E., D.L. Hueth, and M. Phillips, 1987. " Benefits Estimates For Maneb," submitted to the EPA as part of the review process of the fungicide Maneb.

regional impacts vary considerably for some individual crops. Those regions that are highly dependent on maneb tend to suffer significant declines in production although producer surplus in most of the regions increases. The welfare of producers of crops not included in the study and that of processors and distributors increases substantially. The reason that producers and processors gain is due to the inelasticity of demand with reduced output. However, the overall gains experienced by these sectors are overwhelmed by the losses suffered by consumers.

BACKGROUND

The problem of measuring the impacts of these yield effects is complicated for a number of reasons. First, indirect and direct effects may exist in many markets. Second, processors, distributors, and retailers involved in transforming the product from the farm level to the retail level are also affected by price and quantity changes. Third, in the short run producers may not be able to respond quickly whereas in the long run producer supply tends to become more elastic and price effects are attenuated somewhat more.

There are two possible direct effects that can occur as a result of cancelling maneb. First, there could be an increase in the cost of production resulting from a switch to higher cost alternative fungicides. As a result, there would be a decline in the supply of crops that use maneb, and a higher price would be required to induce the same level of producer sales as in the case when maneb is available. If yields also fall, the supply curve would contract still further. Thus, an even higher price would be required to induce producers to maintain sales that are equal to the case in which maneb is used.

As an example, suppose that the original supply curve represented by S in Figure 1 specifies the case in which maneb is used. In this instance producers supply Q at price P. If maneb is canceled the supply curve shifts back to S* since the cost of production increases and yields decline. Producer prices rise since a higher price would be required to induce producers to maintain sales at Q.

Following the principles of applied welfare economics the benefits to producers are measured by the area above the supply curve and below the price line. When maneb is used producers surplus is equal to area a+b. Without maneb, producers' surplus is reduced to area a assuming that producer prices remain at P. If, however, the elimination of maneb causes substantial supply effects they will interact with demand for the crops resulting in price adjustments. If supply decreased a new equilibrium price would be established that reflected the magnitude of the supply decline and the elasticity of demand. The equilibrium price would shift from P to P' and the market quantity at equilibrium would be reduced from Q to Q'. This is higher than Q*, the quantity that would have resulted assuming that prices did not adjust.

At P' producers' welfare is equal to areas d+a. Area d may be larger or smaller than area b depending on the elasticity of demand. Producers are likely to gain if demand is inelastic while they are likely to lose if demand is elastic. Since the demand for most agricultural crops is inelastic, there is a high probability that producers will gain by suspending maneb. In the case of consumers, the principles of applied welfare economics imply that consumers' welfare is roughly represented by the area below the demand curve and above the price line. In Figure 1 consumer welfare if maneb is used is equal to area c+d+e+f. When maneb is not used consumers' surplus is reduced by the area c+d. The total producer plus consumer welfare change is given by area d+a+e+f for a net loss of area b+c. If producers are made better off by the cancellation of maneb, consumers lose more than what is gained by producers since demand is inelastic.

General equilibrium effects must also be considered since consumer price adjustments may result in the substitution for another good. For example, if the price of lettuce increases, consumers might be induced to replace some of their lettuce consumption with spinach consumption, assuming that spinach is not directly affected by the maneb cancellation. In Figure 2 the demand schedule for the substitute good would shift from d to d^* in response to the increased price. The quantity of the substitute good consumed would increase from q to q^*. This increase in the demand for the substitute good would increase the price to P" causing consumers to increase purchases of the first good to q". This results in a loss to consumers of the area r+s+t while producers of the substitute good are made better off by the area r+s. The combined producer and consumer gains and losses results in a net loss of area t.

DATA REQUIREMENTS

Application of the model requires data on prices, quantities, elasticities of supply and demand, and estimates of cost and/or yield effects (see Just et al. 1988). The data were collected for the years 1984-86 and were averaged to minimize the impact of random annual fluctuations in acreage, production, and prices.

Farm level prices were in most cases available from published USDA statistics or from state level publications. The same farm prices were assumed to apply to each region for a particular crop since constant transportation related price differences do not alter the results. Prices corresponding to related crop groups were based on consumer expenditure data at the retail level. Data on the production of each crop in each region as well as total consumption data for the applicable crop groups were also obtained from USDA and state level publications. Consumption data were based on the per capita consumption of all processed and fresh products.

Regional acres of each crop treated with the fungicide maneb and alternatives, cost per acre to apply maneb and alternatives, and yield changes were obtained from extension personnel and others familiar with the crops. The per acre cost of applying maneb varies since it is applied between one and twenty-three times per growing season depending on the region and crop.[6]

Both own and cross price elasticities of demand were collected from the literature for the crops explicitly included in the study. Cross-price elasticities are important if indirect effects are to be captured. Numerous studies of demand have estimated either individual demand elasticities or cross-elasticities for many of the crops that use maneb. However, since maneb affects the prices of many agricultural products that are interrelated in demand, a consistent system of demand elasticities is necessary to obtain a unique determination of consumer welfare effects. The major structural demand systems have been estimated by Brandow (1961), George and King (1971), and Huang (1985). The structural system calculated by George and King was selected for use since there are some troubling large cross price elasticities in the more recent study by Huang that led to implausible results and because the study by Brandow is out of date.[7]

The structural system studies estimate elasticities in a system of ordinary demands that satisfy or approximate reasonable theoretical properties related to budget constraints - namely symmetry, homogeneity, and Engel aggregation (see George and King 1971). Silberberg (1972) has shown that classical measures of economic welfare can be ambiguous and arbitrary where many price changes are involved due to the problem of path dependency. Even the modern concepts of willingness to pay generally become ambiguous and arbitrary when these theoretical restrictions are not imposed in estimation.

George and King's study provides estimates of direct price and income elasticities for 52 commodities. Maneb-using crops not treated explicitly by George and King were included in commodity groups for which their study estimates both direct and cross price elasticities of demand. Fifteen commodity groups were identified as being applicable to the fruits and vegetables in this study. The crop supplies were aggregated across crops within crop groups to investigate their interaction in demand. Remaining crop groups were aggregated into an "all other commodities" category.

Short-run and long-run supply elasticities were needed for each crop and region explicitly included in the study. The supply elasticities were used to determine the response to indirect changes in demand as well as to determine the effect of cost and yield changes on the supply of directly affected crops. Where only national estimates of supply elasticities were available, they were assumed to be the same for all production regions.

In contrast to demand studies, few studies have attempted to estimate the supply of agricultural commodities following a system structure. As an example, Shumway and Chang (1977) used the results of parametric variation of prices in a regional linear programming model as data in estimating supply equations for all the crops in the programming model. The results of the model imply that cross price elasticities in supply can be ignored with little consequence because they are small compared to direct price elasticities. Hence, cross-price elasticities of supply were assumed to be zero here. This assumption does not seem serious because of the regional specificity of many of the crops in the study. Cross price elasticities of supply among crops in the study are likely to be very low while cross price elasticities with crops not in the study are likely to be incorporated in the estimated own elasticities in an equilibrium sense because econometric estimates were not conditioned on prices of competing crops (see Just et al. 1982).

In virtually every case where both short-run and long-run estimates are reported, the supply model follows the popular Nerlovian form which leads to a geometric lag adjustment process. Available estimates in the literature are somewhat disturbing in their lack of consistency and in the lack of estimates for several crops. Many of the elasticities appear to be unreasonably small and the long-run elasticity estimates for 6 of the 9 crops with multiple estimates vary by more than an order of magnitude by crop.

For example, of three studies that estimate supply elasticities for several fruit and vegetable crops, the Hammig (1978) estimates appear to be the smallest, the Nerlove and Addison (1958) estimates are usually somewhat higher, and the Shumway and Chang (1977) econometric estimates are considerably larger. In cases where all three estimates are available, the Shumway and Chang estimates were selected because they are intuitively more plausible and more robust with respect to methodology. In those cases where

Shumway and Chang estimates were not available, the higher of the Hammig and Nerlove-Addison estimates were selected since both studies appear to provide low estimates in comparison to other studies.

In those cases where supply elasticities did not exist, several methods were used to address the problem. For perennial crops such as grapes, zero was used as the short-run supply elasticity since it takes four to seven years to bring new acreage into production. In a few cases, supply elasticity estimates of similar crops were used. In the case of potatoes, estimates by Estes, Blakeslee, and Mittelhammer (1982) were used because of superior regional detail.

Although some of these supply elasticities rely on crude methods, this approach is preferred to assuming that supply is perfectly elastic as has been the traditional practice. Such an approach fails to take into account the fact that some production areas have many cropping alternatives while others have few. In addition, the process of farmer adjustment can only be captured by using elasticities of supply that vary over time.

The relationship between retail and farm level prices is necessary to identify the distribution of effects at the farm and retail levels. The most common measure of these relationships for fruits and vegetables is the elasticity of retail price with respect to farm price which is referred to as the price transmission elasticity. The majority of these were obtained from George and King while the remainder were estimated.[8] These relationships relate changes in farm level supply to consumer demand. They also make possible an investigation of how the welfare of processors and distributors involved in transforming farm-level products into grocery store items is affected (see Just and Hueth 1979).

THE CALCULATIONS

Information concerning regional production quantities and farm level prices were combined with the Nerlovian partial adjustment framework to derive regional supplies for various planning horizons for each crop. The Nerlovian approach was used since most of the available econometric estimates of supply were so derived. As an illustration, suppose that the regional quantity of a particular crop with maneb use is represented by Q_t at time t, the farm-level price is P_f, and that the relevant short-run and long-run elasticities of supply are represented by ϵ and ϵ^* respectively. The regional supply is then given by

$$Q_t = \alpha_0 + \alpha_1 P_f + \alpha_2 Q_{t-1} \tag{1}$$

where at equilibrium

$$\alpha_1 = \epsilon Q_t / P_f$$

$$\alpha_2 = 1 - \alpha_2 P_f / \epsilon^* Q_t$$

$$\alpha_0 = Q_t(1 - \alpha_2) - \alpha_1 P_f.$$

As Nerlove has shown, this approach permits the derivation of supply over any arbitrary planning horizon. For example, a decision to cancel maneb during the current period would cause production of the crop after k production periods to respond according to the supply relationship

$$Q_t = \alpha_0^* + \alpha_1^* P_f \tag{2}$$

where

$$\alpha_1^* = \sum_{j=1}^{k} \alpha_1 \alpha_2^{j-1}$$

$$\alpha_0^* = Q_t - \alpha_1^* P_f.$$

Next suppose that the acreage response for a crop follows

$$L_t = \beta_0 + \beta_1 \pi + \alpha_2 L_{t-1} \tag{3}$$

where L_t is the acreage at time t and π is net return per acre. Net return per acre is further defined as

$$\pi = P_f Y - K \tag{4}$$

where Y is yield per acre and K is the cost of production per acre. Then the implied supply is of the form

$$\begin{aligned} Q_t &= L_t Y = \beta_0 Y + \beta_1 Y \pi + \alpha_2 Y L_{t-1} \\ &= \beta_0 Y - \beta_1 YK + \beta_1 Y^2 P_f + \alpha_2 Q_{t-1} \end{aligned} \tag{5}$$

which is of the same form as above where

$$\alpha_0 = \beta_0 Y - \beta_1 YK$$

$$\alpha_1 = \beta_1 Y^2.$$

Now consider a cancellation of maneb use which entails an increase in cost per acre of K^* and a decrease in yield of Y^*. Supply thus becomes

$$\begin{aligned} Q_t &= \beta_0(Y - Y^*) - \beta_1(Y - Y^*)(K + K^*) + \beta_1(Y - Y^*)^2 P_f + \alpha_2 Q_{t-1} \\ &= \alpha'_0 + \alpha'_1 P_f + \alpha_2 Q_{t-1} \end{aligned} \tag{6}$$

where

$$\alpha'_0 = \beta_0 Y(1 - \delta) - \beta_1 Y(1 - \delta)(K + K^*)$$

$$\alpha'_1 = \beta_1 Y(1 - \delta)^2$$

and δ is the proportional yield reduction with maneb elimination.

Next, these regional supplies with and without maneb use are aggregated over production regions by crop to obtain national supplies by time horizon and crop. Then the national crop supplies at the farm level were transformed into supplies at the retail level by use of the elasticities of price transmission. For example, where the elasticity of price transmission is ω and the retail price is P_r, the relationship of prices can be approximated by a linear relationship

$$P_f = \gamma_0 + \gamma_1 P_r \tag{7}$$

where

$$\gamma_1 = P_f/(\omega P_r)$$

$$\gamma_0 = P_f - \gamma_1 P_r.$$

This relationship can then be used to see how farm and retail prices respond in equilibrium to changes in supply as maneb is eliminated. Substituting this relationship into an aggregate farm level supply of the form $Q_t = \overline{\alpha_0} + \overline{\alpha_1}\, \epsilon *$ obtains

$$Q_t^* = Q_t\phi = [(\overline{\alpha_0} + \overline{\alpha_1}(\gamma_0 + \gamma_1 P_r)]\phi \qquad (8)$$

where Q^* is retail level quantity and ϕ is the conversion factor which converts farm-level weight into retail-level weight. This equation then serves as the retail level supply relationship.

After obtaining retail level supplies for each crop, the individual crop supplies were aggregated into supplies by crop group by adding supplies across all crops within each group. In the case of some of the crop groups, not all of the crops within the group were included in the study. For example, the crop groups "Other fresh vegetables" and " Other canned fruits and vegetables" include numerous crops. In these cases, the supply elasticities of crops included in the study were treated as observations on elasticities for all crops in the group. This assumption seems reasonable since most of these crops have similar characteristics and require similar production inputs; even though these estimates are crude, they are preferred to assuming zero elasticities as in the traditional approach.

In the next step, retail demands were used to solve for equilibrium retail prices without maneb use. The equilibrium crop group prices were then found by setting these demands equal to the crop group supplies without maneb use and solving simultaneously for the prices. The retail prices of individual crops were then found by assuming that individual crop prices within groups adjust proportionally to the crop group price.

The equilibrium farm-level prices assuming no maneb use were found by applying the above equation relating the two prices to the equilibrium retail-level prices of individual crops. Finally, the equilibrium production levels by region and crop were found for the appropriate planning horizon by substituting the equilibrium farm prices into the regional supplies for the case in which maneb is not used.

Welfare changes were then found following the methodology illustrated in Figure 1. The welfare of producers of each crop were computed for each production region as the change in area above supply and below price from the case of maneb use to the case of no use. Consumer welfare was calculated using the Vartia algorithm (1983) which provides a defensible measure of consumer welfare effects including income effects. The algorithm uses income elasticities to convert ordinary demands into compensated demands which are then used to compute willingness to pay measures of consumer welfare change. The resulting welfare effects are approximately unique (non-path dependent) since the system demand estimates were derived under an appropriate theoretical system structure.

In the next step, the welfare effects for processors, distributors, and others involved in the chain between the farm and retail markets were determined. These effects, referred to as processor welfare effects, were examined by conceptualizing a supply of processor services. To derive this relationship the retail level supply equation described above was divided by ϕ to convert to farm level weight

$$Q_t = \overline{\alpha_0} + \overline{\alpha_1}(\gamma_0 + \gamma_1 P_r). \tag{9}$$

Next P^*_r/ϕ was substituted for P_r where P^*_r is defined as the retail price of farm weight equivalents,

$$Q_t = \overline{\alpha_0} + \overline{\alpha_1}(\gamma_0 + \gamma_1 P^*_r/\phi). \tag{10}$$

Then the equation was solved for P^*_r,

$$P^*_r = \phi(Q_t - \overline{\alpha_0} - \overline{\alpha_1}\gamma_1). \tag{11}$$

This yields the retail supply equation in implicit form converted to price and quantity measurements in farm-level equivalents. The farm-level supply that corresponds to this retail supply is given by (1) which in implicit form is represented by

$$P_f = (Q_t - \alpha^*_0)/\alpha^*_1. \tag{12}$$

Subtracting this farm level component of price from the retail level price following the methodology of Just and Hueth (1979) yields

$$P^*_r - P_f = -(\overline{\alpha_0} + \overline{\alpha_1}\gamma_0)/(\overline{\alpha_1}\gamma_1) - \alpha^*_0/\alpha^*_1 + (\alpha^*_1\phi + \overline{\alpha_1}\gamma_1)/(\alpha^*_1\,\overline{\alpha_1}\gamma_1)Q_t \tag{13}$$

which represents the processor supply of services in implicit form. Here $P^*_r - P_f$ is the price processors receive for transforming one unit of farm produce into its equivalent retail form. The change in processor welfare is then found as the change in area above this supply curve and below the associated price.

Finally, the welfare effects on producers of other crops were considered. These crops include those that fall within the group of crops in the demand system but are not explicitly included in the list of individual crops using maneb. These are evaluated using the difference between crop group supplies discussed above and the sum of supplies over individual crops within the relevant crop groups included explicitly in the study. This difference represents the supply of other crops so the associated change in area above this supply and below price measures the change in welfare for producers of other crops.

The changes brought about by maneb elimination may also cause some small price effects on commodities other than fruits and vegetables because of cross price effects of demand. For the purposes of this study the supplies of these other commodity groups are assumed to be perfectly elastic since these effects tend to be negligible (see George and King 1971).

RESULTS AND DISCUSSION

Table II presents aggregate producer welfare effects for each crop for the two scenarios for several time horizons. In the first scenario, the elimination of maneb has relatively mild effects on most of the crops except for sweet peppers and spinach, both of which suffer substantial yield losses (see Table I). As a result of these yield reductions, cross price effects cause the prices for other fruits and vegetables to be bid up by varying amounts. Whether producers of each crop experience a gain or loss depends partly on how the cross price effects compare to the increases in production costs caused by the use of more expensive fungicides. It also depends partly on how the cross price effects compare to the supply adjustments resulting from cost increases.

In the second scenario, the elimination of maneb has the largest welfare effects on producers of lettuce, tomatoes, and potatoes. Lettuce producers achieve large gains because yields are reduced and demand is highly inelastic. This causes lettuce prices to be bid up by 61 percent during the first year. They also achieve gains because both chemical and application costs are eliminated. Producers of fresh tomatoes and fresh potatoes also achieve large

Table II

Producer Welfare Effects of Maneb Suspension (Thousand Dollars)

Crop	Scenario I: No Replacement by EBDC's			Scenario II: No Replacement by EBDC's or Bravo		
	One Year	Two Year	Five Year	One Year	Two Year	Five Year
Apples, Fresh	-471	-476	-479	11,646	11,574	11,507
Apples, Processed	166	-87	-359	-22,5044	-3,097	
Beans, Edible Dry	312	1,406	1,275	7,439	3,099	-167
Beans, Snap Fresh	-687	-620	-491	8,196	2,800	-1,808
Beans, Snap Processed	1,946	1,389	822	4,283	3,053	1,813
Broccoli	283	247	247	4,371	3,573	2,887
Brussels Sprouts	23	27	28	1,131	1,051	1,017
Cabbage	4,734	3,292	2,062	-3,081	-10,979	-18,230
Cantaloupe	-627	-106	-104	1,918	701	81
Carrots, Fresh	-695	-622	-422	20,280	13,614	7,453
Carrots, Processed	241	144	60	147	-101	-362
Cauliflower	191	174	191	-1,664	-2,282	-2,742
Celery	5,561	4,091	2,852	40,506	30,164	19,629
Corn, Sweet Fresh	4,084	2,787	2,116	36,667	26,774	17,049
Cucumbers, Fresh	1,676	1,267	1,052	17,596	13,605	9,463
Cucumbers, Processed	2,341	1,717	1,188	5,974	4,119	2,163
Grapes, Fresh	97	113	113	360	-635	-1,657
Grapes, Processed	-393	-397	-402	-6,715	-6,800	-6,879
Honeydew	-5	24	24	717	480	266
Lettuce	-203	-196	-8	232,378	145,484	77,713
Onions	-1,389	-937	-291	58,981	38,548	25,301
Peppers, Sweet	-24,423	-25,516	-26,344	12,857	4,270	-4,426
Potatoes, Fresh	296	295	294	34,704	34,684	34,665
Potatoes, Processed	-7,157	-6,091	-4,173	-24,997	-27,656	-30,455
Spinach	-13,925	-13,771	-13,705	-12,877	-13,014	-13,212
Squash	735	446	323	536	-301	-1,193
Sugar Beets	-207	-209	-210	-607	-821	-924
Tomatoes, Fresh	-6,760	-5,776	-3,911	72,344	49,939	28,181
Watermelon	-4,881	-4,253	-3,689	3,560	1,749	-78

gains for similar reasons although the relative price adjustments are only 19 and 15 percent, respectively. In contrast, since the price effect for processing potatoes is small (3 percent), substantial yield losses (23 percent) are not offset.

Table III lists the results of the short-run (one year) effects of banning maneb and/or maneb alternatives for seven crops that experienced significant regional impacts.[9] These results indicate that the impact of banning maneb vary considerably between regions for the same crop due to different regional yield effects, material costs, treatment acres, and per acre baseline yields. The regional impacts are much greater when maneb and maneb alternatives are not available.

Sweet peppers and spinach are the only two crops that experience significant regional impacts in the first scenario since they have no viable alternative fungicides. The production of both crops drops sharply in most of the regions while prices increase only marginally. As a result producer welfare also declines sharply. For example, spinach production in California and Texas falls by over 40 percent and in the Mid-Atlantic by over 76 percent. However, since farm level prices only increase by 1.7 percent, producer welfare in the first two regions falls by over 40 percent and by over 87 percent in the third region. In the aggregate, producer welfare falls by 22.5 percent.

When maneb and maneb alternatives are not allowed the regional impacts are much greater. Since the demand for the majority of crops included in the study are fairly inelastic, production declines are more than offset by increases in farm level prices. Although the declines in sweet pepper production are similar to the first scenario, farm level price increases are

Table III

Selected Short-Run Regional Production, Farm Price, and Welfare Effects of Banning Maneb and Maneb Alternatives

Crop/Region	No EBDCs			No Alternatives		
	Production	Price	Welfare	Production	Price	Welfare
	- - - - - - - - - - Percent change - - - - - - - - - - - - - - -					
<u>Sweet Peppers</u>	-11.37	1.96	-9.31	-10.88	17.57	4.90
Florida	-22.61	1.96	-20.60	-22.24	17.57	-8.22
Texas	.08	1.96	2.00	.68	17.57	17.98
Other Regions[a]	-9.00	1.96	-6.92	-8.50	17.57	7.69
<u>Spinach</u>	-27.78	1.71	-22.48	-27.40	3.69	-20.79
California	-43.36	1.71	-40.07	-43.14	3.69	-38.77
Mid-Atlantic	-76.87	1.71	-87.14	-74.10	3.69	-83.88
Texas	-47.24	1.71	-43.88	-47.11	3.69	-42.72
Other Regions	.22	1.71	1.83	.48	3.69	3.96
<u>Fresh Sweet Corn</u>	.40	2.95	2.16	-5.63	26.41	19.40
Southeast	.34	2.95	.69	-19.58	26.41	4.06
California	.44	2.95	3.19	3.96	26.41	29.12
Pacific Northwest	.44	2.95	3.19	3.96	26.41	29.12
Northeast	.44	2.95	2.59	2.43	26.41	29.24
Mid-West	.44	2.95	3.00	5.62	26.41	18.14
Texas	.44	2.95	3.19	3.96	26.41	19.40
<u>Lettuce</u>	.01	.21	-.03	-3.71	47.22	37.79
Desert	.05	.21	.16	9.58	47.22	54.84
California-Other	.03	.21	.13	-11.09	47.22	28.20
Other Regions	-.34	.21	-2.09	-10.38	47.22	30.17
<u>Fresh Potatoes</u>	.08	.35	.17	2.62	10.99	19.99
Desert	.61	.35	1.22	14.39	10.99	37.66
Pacific Northwest	.43	.35	.87	-2.59	10.99	11.85
Maine	-1.75	.35	-3.47	-1.36	10.99	15.12
Other Regions	.08	.35	.17	3.76	10.99	21.70
<u>Fresh Snap Beans</u>	-.09	.18	-.81	-11.76	25.01	9.72
Florida	-.25	.18	-2.21	-33.13	25.01	-14.85
Other Regions	.03	.18	.19	3.75	25.01	27.55
<u>Fresh Tomatoes</u>	-.04	.14	-.99	-6.12	17.72	10.56
Florida	-.08	.14	-1.57	-9.91	17.72	6.73
Other Regions	.004	.14	-.43	-2.40	17.72	14.32

[a] Due to the space limitations some regions were combined with the "other regions" category. The percentages for production and welfare changes in "Other Regions" were calculated by multiplying each region's percentages by the corresponding regional share of total remaining production. The resulting numbers were then summed.

nine times higher. As a result sweet pepper producers experience an aggregate increase in welfare of 4.9 percent rather than a decline. In contrast, since spinach price increases are only two and one half times as large as in the first scenario while production declines are approximately the same, producer welfare still declines sharply.

In addition to sweet peppers and spinach the elimination of maneb and maneb alternatives significantly affects the regional production of a number of other crops including fresh sweet corn, lettuce, fresh potatoes, fresh snap beans, fresh tomatoes, and other crops. In the majority of cases aggregate production declines, combined with large price increases, result in large increases in producer surpluses, although regional impacts vary depending on the degree of dependence on maneb. For example, the regional production of fresh sweet corn falls by 19.6 and 5.6 percent in the Southeast and Midwest regions respectively, both of which treat a significant portion of their acreage with maneb, while it increases between 2.4 and 4 percent in the remaining regions which use little or no maneb. Since farm level prices increase by 26.4 percent aggregate producer welfare increases by nearly 20 percent, while it increases between 4 and 29 percent at the regional level.

Table IV lists the aggregate welfare effects on producers who use maneb, producers of other crops that do not use maneb, processors and distributors, and consumers. Assuming the availability of alternative fungicides, producer losses in the first scenario range between 39 and 42 million dollars per year after five years of adjustment. In general, producers of spinach and sweet peppers lose, while producers of other crops are relatively unaffected. In the second scenario, producers of crops that use maneb initially gain 525 million dollars which declines to 154 million dollars per year after five

Table IV

Welfare Effects of Maneb Suspension (Million Dollars)

Market Group	Scenario I: No Replacement by EBDC's			Scenario II: No Replacement by EBDC's or Bravo		
	One Year	Two Year	Five Year	One Year	Two Year	Five Year
Producers Using Maneb	-39	-42	-42	525	324	154
Other Producers	362	272	184	3,119	2,434	1,753
Processors & Distributors	-16	-36	-63	1,276	755	337
Consumers	-879	-678	-484	-13,445	-10,663	-8,129
Net Effect	-573	-484	-405	-8,525	-7,150	-5,886

years of adjustment. This occurs because decreases in per acre yields which lead to price increases are largely offset by an increase in acreage.

Processors and distributors in the first scenario are generally affected less than producers of crops that use maneb since quantities moving through the food marketing chain are relatively unaffected. In the second scenario these groups experience welfare changes that are nearly twice as high as are those for producers since the reduction in marketed quantities results in less demand for processor services.

The bulk of the welfare effects of maneb suspension are experienced by consumers and producers of crops not currently using maneb. In the case of other producers, the reduction in supplies of maneb using crops also bids up the prices of unaffected fruits and vegetables. The higher prices are a pure gain on current output and induce higher output from which further benefits are realized. In contrast, consumers must pay higher prices for the products which currently use maneb as well as for products for which prices are bid up through competition with maneb-reduced supplies. The impacts on consumers range between 879 and 484 million dollars per year after five years of adjustment in the first scenario, and between 13 and 8 billion dollars in the second scenario.

Although the farm-level revenues obtained from crops that use maneb is only 9.6 billion dollars, annual consumer expenditures on the fruit and vegetable crop groups considered in this study amount to over 202 billion dollars. Consumer expenditures on crops that use maneb is equal to well over half of this amount. Thus, a consumer welfare effect of .9 billion dollars in the first scenario and 13.5 billion dollars in the second scenario is only .5 and 6.4 percent, respectively, of consumer expenditures on the relevant crop groups.

CONCLUSIONS

The results of this paper illustrate several important principles that must be included in serious analyses of pesticide suspensions. First, the results show that regulatory decisions that only consider one pesticide at a time can lead to significantly different results than if a group of related pesticides is considered jointly. In this paper, the suspension of maneb assuming substitutes are available has minimal impacts on producers and consumers. However, the impacts are much greater when the major maneb alternative -- Bravo -- cannot be used to replace maneb. This large impact is separate from the value of using Bravo on the acreage on which it is currently applied.

Second, the results demonstrate that the distribution of effects of pesticide suspension depend critically on regional differences among production areas. In this study, the extent of use and the impact on yields of maneb differs substantially among regions. These conditions cause producers in some regions to lose from suspension while producers in other regions gain due to the redistribution of production that occurs with suspension.

Third, this study demonstrates that producers who do not currently use the pesticide subject to suspension can experience larger welfare effects than users due to equilibrium adjustments. The results here show that users of maneb experience offsetting effects. Maneb suspension tends to cause loss because yields decline but inelastic demand causes reduced production to translate into higher prices. In contrast, producers of the same crop and of substitute crops who do not use maneb gain both from higher prices and from increasing acreage in response to the higher prices.

Fourth, the results here show how the bulk of welfare effects can occur as downstream effects in the processing and consuming sectors. Reduced production caused by maneb suspension causes a substantial decline in demand for processor services (when Bravo replacement is not allowed). Nevertheless, final product cannot be produced without the basic fruit or vegetable input. Since the farm level product accounts for only a small part of the value of the final consumer fruit or vegetable product, the economic effects at the retail level can be much larger.

Finally, the results illustrate the principle noted in previous research that farmers can benefit from restrictions on input use because with inelastic demand reduced output translates into higher profits.

While the results here demonstrate some important principles for evaluating pesticide suspension, the specific numerical results must be regarded with careful skepticism. Some of the data and most of the elasticity estimates are not recent and may no longer be appropriate. Also, the regional information on maneb use, efficacy, and alternatives is in some cases of questionable reliability since it was collected as primary data in direct field interviews. The view here is that poor estimates of elasticities and poor information on regional differences in cost and yield effects is better than ignoring them altogether as in traditional methodologies.

The important sensitivities of the results to regional differences and elasticities demonstrates the importance of improving public data sources on yield effects, application costs, efficacy, and supply response regionally as well as demand elasticities and cross elasticities nationally. The latter cross elasticities are needed not only with respect to crops affected directly by suspension but also by important substitute crops. Until such information is compiled on a systematic basis, calculation of pesticide benefits will continue to be empirically weak because of poor and missing data and outdated elasticity estimates or, more seriously, structurally weak because of having to assume away regional and cross commodity effects.

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ENDNOTES

1. EBDC (Ethylene Bisdithiocarbamates) fungicides are an important group of chemicals that are highly effective at controlling a variety of foliar diseases and molds such as downy mildews, rusts, late and early foliar blights, leaf spots, fruit rots, and anthracnose. Since being introduced in the late 1940s, they have been widely used on 72 fruit, vegetable and field and ornamental crops to control 420 diseases. Maneb, which is one of the most commonly used EBDC fungicides, has no phyto-toxic side effects, is relatively inexpensive, does not promote pathogen resistance to fungicides, and is compatible with many other pesticides that are commonly used. (Thompson, 1983).
2. This review was called for as a result of scientific studies which indicated that an EBDC metabolite, ethylenethiourea (ETU), was oncogenic to the thyroid of rats and liver of mice (Innes (1969), Carlton (1986), Hunter et al. (1979), Graham et al. (1975)), caused thyroidal functional and morphological effects in animals (Graham and Hanson (1972), Freudenthal et al. (1977)), and showed evidence of teratogenicity in rats and hamsters (Khera (1973), and Teramoto (1978)). See 52 Federal Register 27172, July 17, 1987.
3. Some crops such as broccoli, bell peppers, beans, cabbage, cauliflower, sweet corn, lettuce, potatoes, fresh tomatoes, and spinach are highly dependent on the use of maneb to prevent serious yield losses. Yield losses assuming that no alternative is available range from 12 percent for broccoli, brussels sprouts and cauliflower to 57 percent for fresh sweet corn.

4. Acreage currently using EBDC's other than maneb is unaffected. If all EBDC's are eliminated, the direct effects on the crops considered in the study could be more severe since some EBDC fungicides are used on many of the same crops. In addition, since alternative EBDC's are also used on other crops that are related in demand to the crops included in the study, the cross price effects due to consumer substitution would result in additional effects.

5. For many of the crops there are alternatives such as ridomil, folpet, and chlorothalonil (Bravo). However, many of the alternatives eventually lead to disease resistance, have reduced efficacy, are more expensive, have a narrower spectrum than the EBDC fungicides, and/or may or may not be as compatible with other pesticides (Buhn, 1987).

6. The changes in per acre costs assuming that there is an alternative to maneb were calculated for each crop and region by multiplying the per acre cost differences by the number of maneb treatment acres. A treatment acre is defined as the number of times a planted acre is treated with maneb. This number was then divided by the total number of planted acres treated with maneb. Cost changes assuming no alternatives, were calculated by multiplying the percentage of the maneb treatment acres by the application costs per acre and by the percentage of the treatment applications which are eliminated if maneb is no longer used. This number was then multiplied by the ratio of the maneb treatment acres to the total number of acres planted treated with maneb in each region. The resulting number was added to the money saved by not having to purchase fungicides, which was obtained by multiplying the number of treatment acres by the cost of the fungicide divided by the number of planted acres treated with maneb.

7. One can also criticize the use of the George and King estimates because of their age but no better alternative is available. Originally, this study intended to use the Huang estimates because they were more recent. However, there were problems with some of the elasticities. For example, the cross price elasticity between carrots and apples led to implausible interaction between the two crops in determining equilibrium price adjustments due to the elimination of maneb. Several of the cross price elasticities exceed unity, such as the one between canned tomatoes and non-food items. Because of these implausible estimates, the final results of this study use the somewhat older George and King estimates.

8. George and King estimate and report transmission elasticities for only a subset of the crops considered in the study. To complete the transmission elasticities, an equation was postulated which represents the transmission elasticity as a function of the farm level conversion factor, the retail price, and the farm price. This seems reasonable because most of the processing activities use similar inputs so that differences are roughly a function of the share of the final product held by the farm-level product. This share is roughly reflected by the difference in farm and retail prices after correcting for the weight conversion factor. The price transmission elasticity equation estimated using George and King's individual estimated elasticities as data on the dependent variable is:

$$\underset{(2.10)}{\text{Log}(g) = -6.24} - \underset{(.559)}{.870}\,\text{Log}(Z) + \underset{(.320)}{.445}\,\text{Log}(P) + \underset{(.2696)}{.0933}\,\text{Log}(F),\quad R^2 = .76$$

where standard errors are reported in parentheses and where g is the transmission elasticity, Z is the farm level conversion factor, P is the retail price, and F is the farm level price.

9. Other crops were not included due to space limitations. For further detailed information please refer to Just et al. (1988).

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