The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

REPLACEMENT OF PRICE SUPPORT MEASURES BY DIRECT PAYMENTS IN AGRICULTURAL POLICIES. DOES THIS BENEFIT THE ENVIRONMENT? THE EFFECTS OF THE POST-1992 CAP ON PEST CONTROL IN THE E.U.

Teresa Serra, David Zilberman, Barry K. Goodwin, and

Keijo Hyvonen

Visiting Scholar at the University of California, Berkeley; Professor at the University of California, Berkeley; Professor at North Carolina State University; and Head of unit "Analysis of the Situation of Agricultural Holdings," European Commission, Agriculture Directorate-General respectively.

Corresponding author: David Zilberman, University of California, Berkeley, Department of Agricultural and Resource Economics, 207 Giannini Hall # 3310, Berkeley, CA 94720-3310, E-mail: zilber@are.berkeley.edu

The authors gratefully acknowledge technical support from Patrick Van-Driessche.

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Denver, Colorado, July 1-4, 2004

Copyright 2004 by Serra, Zilberman, Goodwin and Hyvonen. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Introduction

Developed countries have a tendency to provide income support to farmers (see, for example, Gardner (1992, 2002), and Rude). An extensive literature has documented the impacts of income-support measures on farmers' production decisions, such as chemical inputs, water or land use (Antle and Just). Though agricultural policies can have complex effects, the analysis of input use generally shows that when the support is being of the form of price-support measures, it will result in an intensification of farming practices that in many cases can result in significant environmental effects.[1] The economic literature has also shown that pollution effects of agricultural policies can be mitigated with an appropriate policy design and administration (Just and Antle; Liapis). The political pressure to support farmers combined with the desire to reduce efficiency losses and environmental spillovers, has led to the design of decoupled support programs. The main idea behind decoupling is the increase in the efficiency of agricultural policy (Chambers 1992). Specifically, decoupled programs pursue the objective to continue to provide farm income support, while creating the necessary conditions to motivate farmers' decisions to be based only on market considerations (Rude). Welfare economics views lump sum transfers as the most efficient method to redistribute income among different individuals (Williamson), because their recipients cannot alter the transfer amount by changing their behavior in any fashion.[2] According to this theory, many domestic agricultural policies have been reformed worldwide to reduce price-support measures in favor of direct payments to farmers. The MacSharry reform of the Common Agricultural Policy (CAP) is one example of an attempt to increase the decoupled element of farm income support in Europe, and the purpose of this article is to assess the impact of this policy on the use of crop protection products.

The economic support, especially price-support measures, provided to European farmers under the CAP and under the national policies before the implementation of the CAP, technological developments, as well as commercial considerations to maximize profits, have contributed to the intensification of the European agriculture, especially during the last 40 years (Commission of the European Communities). As a result of changes in agricultural practices such as continuous cropping, high input usage, increase of irrigation practices, or the planting of highly productive crop varieties, crop yields have increased steadily and continue to do so. However, intensification of farming has resulted in environmental damages such as the contamination of both ground and surface water and the loss of biodiversity as a result of the decline of natural habitats (Commission of the European Communities).

A relevant source of pollution derived from the agricultural activity is the use of crop protection products, in particular, pesticides. Concerns about the environmental effects of pesticides have led to call for integrating environmental considerations into the European Union (E.U.) policies including the CAP.

As a result of both inefficiencies and budgetary burdens generated by Europe's farm programs and international pressures to reduce trade distortions, the E.U. reformed its CAP during the 1990s. With the 1992 MacSharry reforms, the CAP was changed from a policy mainly based on price management towards a more market-oriented policy. This represented an important modification of the way Europe's agricultural policies provide income support to farmers. The reforms made special emphasis on arable crops (cereals, oilseeds, and protein crops) and implied substantial reductions in the guaranteed prices for these crops. Intervention prices for cereals were reduced by approximately one-third and simplified to a common single price. The institutional prices for protein crops[3] were abolished. The effects of these price reductions or abolitions on farms' incomes were compensated by crop-specific direct payments, which were defined on the basis of historical regional average yields and historical arable crop areas.[4] For professional producers,[5] the perception of the per hectare payments was made conditional upon setting aside a fixed percentage of program crop areas. In recompense, they would receive a set-aside compensatory payment.[6]

To the extent that MacSharry CAP reforms in the arable crop regime could have stimulated a more precise application of agricultural inputs and management techniques, the new CAP could have affected the natural environment, by altering the use of crop protection products such as pesticides. Although changes in pesticide usage depend on many factors, since the 1990s a slowdown in pesticide applications has been registered in the E.U. (Boatman et al.). This reduction could, of course, be attributed to various causes: weather conditions such as droughts that can slow demand, seasonal conditions, crop mixes, input prices, set aside of agricultural land, increasing availability of low application rate pesticides, national policies, the new agri-environmental measures, etc. (Boatman et al.). As mentioned above, the objective of this research is to determine the contribution of recent agricultural policy reforms in the E.U. on changes in the use of crop protection products. Specifically, the analysis will focus on quantifying the effects on the application of crop protection products derived from the reduction of price-support measures in favor of income-support mechanisms in the cereal, oilseed and protein crop (COP) sector.

The Model

A theoretical model aimed at analyzing the effects of the post-MacSharry CAP on production decisions should consider that, although compensatory payments are based on historical areas and yields, they are not fully decoupled from production decisions (see, for example, Moro and

Sckokai; Guyomard, Baundry, and Carpentier; or Oude Lansink and Peerlings). Instead, these payments are tied to the obligation to produce certain crops,[7] as well as to the compulsory set aside of some land. As a result, these payments have been found to have an influence on the allocation of land and thus on production decisions (see Guyomard, Baundry, and Carpentier; and Moro and Skokai).

In order to be able to assess the influence of the COP regime on the use of crop protection inputs, we consider a multi-output model. Following previous research (Guyomard, Baundry, and Carpentier; Moro and Skokai), we assume land as a fixed but allocable factor. Our model adopts a behavioral approach in that it studies the impacts of the COP regime through the dual representation of the production technology. The use of the duality approach, which has been extensively employed to study the COP regime effects on production decisions (see Guyomard, Baundry, and Carpentier; Oude Lansink and Peerlings; or Moro and Skokai for some examples), is motivated by the fact that data are not available on input allocations among different crops.[8] In order to recognize the particular role of crop protection products as damage-control inputs, we adopt the multi-output generalization of the Lichtenberg-Zilberman damage control technology model developed by Chambers and Lichtenberg through dual representations.

Consider a multi-output firm that produces two outputs $\mathbf{Y} = (Y_1, Y_2)$. We represent the multi-output production technology through a production possibilities set $T = \left[(\mathbf{Y}, X, \mathbf{A}, \mathbf{g}, L, K, A, W) : (X, \mathbf{A}, \mathbf{g}, L, K, A, W) \text{can produce } \mathbf{Y} \right]$. X represents the quantity utilized of a directly productive variable input. L and K are quasi-fixed inputs, where L symbolizes labor and K represents capital. $\mathbf{A} = (A_1, A_2)$ is the vector of land allocation, which satisfies $A_1 + A_2 = A$. The land allocated to the production of crop k is represented by A_k and

A stands for total acreage. W represents weather conditions. $\mathbf{g} = (g_1, g_2)$ is a vector that contains the damage abatement functions for crops 1 and 2. These functions recognize the distinct contribution of damage control agents to agricultural output, which is different from the contribution of standard inputs. g_k defines the role of damage control agents to production of crop k in terms of their capacity to reduce crop damage. It is represented by a nondecreasing concave function $g_k = G_k(z_k)$, where z_k symbolizes the application level per acre of a control input to crop k.[9] Abatement cannot exceed the potential output (Lichtenberg and Zilberman). This implies that the abatement functions $g_k = G_k(z_k)$ must be defined in the (0,1) interval, with $G_k = 1$ representing perfect abatement and $G_k = 0$ denoting no abatement. $\pi(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W)$ is the profit function dual to T. This function represents the profit-maximizing program of agricultural producers and may be written as:

$$\pi(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W) + qQ =$$

$$\max_{\mathbf{Y}, X, \mathbf{A}, Z_1, Z_2} \left\{ \mathbf{pY} - wX + \mathbf{copA} - vZ_1 - vZ_2 : A_1 + A_2 = A; \left[\mathbf{Y}, X, \mathbf{A}, \mathbf{g}, L, K, A, W \right] \in T \right\} + qQ \quad (1)$$

where $\mathbf{p} = (p_1, p_2)$ is a vector of output prices, w is the standard variable input price, $\mathbf{cop} = (cop_1, cop_2)$ is a vector of compensatory payments per hectare of land planted to crops 1 and 2 respectively, v is the price of the damage control input, Z_k is the total application of damage control agents to crop k, q represents set-aside payments, and Q represents the hectares being set aside. In our model, the areas set aside, as well as set-aside payments, are considered as exogenous variables. $\pi(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W)$ is linearly homogeneous and convex in prices, nondecreasing in prices, nonincreasing in input prices, and nondecreasing in total labor, capital, and acreage.

Following Chambers and Lichtenberg, the profit maximization problem can be decomposed into two main problems: a restricted profit maximization and cost of abatement minimization.

$$\pi(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W) =$$
$$\max_{\mathbf{Y}, X, \mathbf{A}, g_1, g_2} \left\{ \mathbf{pY} - wX + \mathbf{copA} - \min_{z_1} \left[vZ_1 : G_1(z_1) \geq g_1 \right] - \min_{z_2} \left[vZ_2 : G_2(z_2) \geq g_2 \right] : \right.$$
$$\left. A_1 + A_2 = A; (\mathbf{Y}, X, \mathbf{A}, g_1, g_2, L, K, A, W) \in T \right\} =$$

$$\max_{g_1, g_2} \left\{ \max_{\mathbf{Y}, X, \mathbf{A}} \left[\mathbf{pY} - wX + \mathbf{copA} : A_1 + A_2 = A; (\mathbf{Y}, X, \mathbf{A}, g_1, g_2, L, K, A, W) \in T \right] - \right.$$
$$\left. c_1(v, g_1) - c_2(v, g_2) \right\} =$$

$$\max_{g_1, g_2} \left[R(\mathbf{p}, w, \mathbf{cop}, L, K, A, W; g_1, g_2) - c_1(v, g_1) - c_2(v, g_2) \right] \tag{2}$$

where c_k is the cost of the abatement function of output k, which is linearly homogeneous, concave in v, nondecreasing in v, and nondecreasing and convex in g_k. The cost of the abatement function satisfies the Shepard's lemma in that $Z_k(v, g_k) = \frac{\partial c_k(v, g_k)}{\partial v}$. $R(\mathbf{p}, w, \mathbf{cop}, L, K, A, W; g_1, g_2)$ is a restricted profit function that is defined for given abatement levels, and that excludes abatement costs. The restricted profit function is linearly homogeneous and convex in prices, nondecreasing in prices, nonincreasing in input prices, nondecreasing in quasi-fixed inputs, and nondecreasing and concave in g_k.

The optimal abatement level $g_k(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W)$ for crop k can be determined by equating the abatement marginal return to its marginal cost:[10]

$$\frac{\partial R(\mathbf{p}, w, \mathbf{cop}, L, K, A, W; g_1, g_2)}{\partial g_k} = \frac{\partial c_k(v, g_k)}{\partial g_k} \tag{3}$$

Optimal crop supplies, optimal input demands and optimal land allocations can be obtained by applying the Hotelling-Shephard lemma to expression (2). By omitting the arguments of the functions this yields:

$$Y_i = \frac{\partial R}{\partial p_i} \ , \ X = -\frac{\partial R}{\partial w}, \ A_i = \frac{\partial R}{\partial cop_i} \ , \text{ and } Z_i = \frac{\partial c_i}{\partial v} , \tag{4}$$

where $i = 1, 2$.

If CAP compensatory payments were completely decoupled from production, we would expect that their increase would not affect the use of damage abatement inputs, but since compensatory payments are only partially decoupled, we anticipate an increase in the use of these inputs. However, we expect the payment elasticity of damage abatement products to be smaller than their output price elasticity. The key point of the article is that compensatory payments have a lower impact on the use of damage abatement inputs than regulated prices. To quantify this assumption we compute the elasticity of the demand of damage control inputs with respect to the agricultural policy measures (regulated prices and per hectare compensatory payments). These elasticities are long-run measures in that they do not assume a fixed abatement level:

$$\varepsilon_{z_k cop_1} = E_{y_1 cop_1} E_{Z_k y_1} + E_{y_2 cop_1} E_{Z_k y_2} + E_{A_1 cop_1} E_{Z_k A_1} + E_{A_2 cop_1} E_{Z_k A_2}$$

$$\varepsilon_{z_k cop_2} = E_{y_1 cop_2} E_{Z_k y_1} + E_{y_2 cop_2} E_{Z_k y_2} + E_{A_1 cop_2} E_{Z_k A_1} + E_{A_2 cop_2} E_{Z_k A_2}$$

$$\varepsilon_{z_k p_1} = E_{z_k p_1} + E_{y_1 p_1} E_{Z_k y_1} + E_{y_2 p_1} E_{Z_k y_2} + E_{A_1 p_1} E_{Z_k A_1} + E_{A_2 p_1} E_{Z_k A_2}$$

$$\varepsilon_{z_k p_2} = E_{z_k p_2} + E_{y_1 p_2} E_{Z_k y_1} + E_{y_2 p_2} E_{Z_k y_2} + E_{A_1 p_2} E_{Z_k A_1} + E_{A_2 p_2} E_{Z_k A_2}\,, \qquad (5)$$

where ε_{xy} represents the elasticity of variable x with respect to y. As (5) shows, the long-run compensatory payment and price elasticities of Z_k are the sum of the short-run Z_k elasticities with respect to policy measures and the product of the compensatory payment and price elasticities of output and hectares by the respective Z_k output and hectare elasticities. Our hypothesis involves $\varepsilon_{z_k cop_1} < \varepsilon_{z_k p_1}$ and $\varepsilon_{z_k cop_2} < \varepsilon_{z_k p_2}$.

Econometric Estimation

Because data on damage abatement are rarely observed, the usual practice is to specify a parametric representation of G_k. Following previous work on damage control in agriculture, we adopt the exponential function: $G_k(z_k) = 1 - e^{-\lambda_k z_k}$, where λ_k is a parameter. The cost abatement function that corresponds to this exponential specification is: $c_k(v, g_k) = -vA_k \dfrac{\ln(1-g_k)}{\lambda_k}$. In order to consistently estimate the equations in (4), we follow the two-step process outlined by Chambers and Lichtenberg. In the first step, we derive a consistent estimate of g_k ($\hat{g}_k$). To do so, we use the solution to (3) to estimate the parameters of the abatement cost functions, $c_k(v, g_k)$. It can be shown that equating the abatement marginal return to the abatement marginal cost yields the following expression of the damage abatement function:

$$g_k = \frac{\lambda_k (p_k Y_k)}{vA_k + \lambda_k (p_k Y_k)} . \tag{6}$$

By substituting $G_k(z_k) = 1 - e^{-\lambda_k z_k}$ into expression (6), we derive the equation of the optimal level of pesticide usage on crop k :

$$Z_k = \frac{A_k}{\lambda_k}\left[-\ln vA_k + \ln(vA_k + \lambda_k (p_k Y_k)\right]. \tag{7}$$

Thus, the total consumption of crop protection products can be expressed as:

$$Z = \sum_{k=1}^{2} \frac{A_k}{\lambda_k}\left[-\ln vA_k + \ln(vA_k + \lambda_k (p_k Y_k)\right]. \tag{8}$$

It is important to note that equation (8) not only allows estimating the parameters of the abatement cost functions, but also allocates total consumption of crop protection products between the k crops. In order to estimate equation (8), we first make assumptions about farmers' price and yield expectations from which we derive $\widehat{p_k Y_k}$. Equation (8) is then estimated by nonlinear least squares using the predicted $\widehat{p_k Y_k}$. To approximate $\widehat{p_k Y_k}$, we adopt assumptions concerning farmers' price and quantity expectations. Any assumption about the formation of expectations for cereal prices should consider the role of the intervention price.[11] The expected price for cereals is approximated by the maximum between the lagged value of market price and the intervention price.[12] For oilseeds and protein crops, we simply take the lagged market price to form price expectations.[13] To form expected values of the production vector $\mathbf{Y}=\left(Y_1,Y_2\right)$, we regress the actual yields against a time trend and the farm's yields over the past two years.[14] The predicted values are then multiplied by the hectares planted to each respective crop, thus deriving $\hat{\mathbf{Y}}=\left(\hat{Y}_1,\hat{Y}_2\right)$.

Equations Y_1, Y_2, X, A_1, and A_2 in (4) are estimated using Zellner's SUR technique. To be able to estimate these functions, we approximate the restricted profit function by a normalized quadratic function defined on normalized variable input prices.

$$R(p_1,p_2,cop_1,cop_2,L,K,A,W)=b_0+b_1f+f\,'b_2f\ , \tag{9}$$

where $f=(p_1,p_2,cop_1,cop_2,L,K,A,W)$.[15]

By imposing symmetry, $b_{ij}=b_{ji}$, where $i\neq j$, $i=(p_1,p_2,cop_1,cop_2,L,K,A,W)$, and $j=(p_1,p_2,cop_1,cop_2,L,K,A,W)$, the optimization conditions can then be expressed as:

$$\begin{aligned}
Y_1 &= b_{p_1}+2b_{p_1p_1}p_1+2b_{p_2p_1}p_2+2b_{cop_1p_1}cop_1+2b_{cop_2p_1}cop_2+2b_{Lp_1}L+2b_{Kp_1}K+2b_{Ap_1}A+2b_{Wp_1}W\\
Y_2 &= b_{p_2}+2b_{p_1p_2}p_1+2b_{p_2p_2}p_2+2b_{cop_1p_2}cop_1+2b_{cop_2p_2}cop_2+2b_{Lp_2}L+2b_{Kp_2}K+2b_{Ap_2}A+2b_{Wp_2}W\\
A_2 &= b_{cop_2}+2b_{p_1cop_2}p_1+2b_{p_2cop_2}p_2+2b_{cop_1cop_2}cop_1+2b_{cop_2cop_2}cop_2+2b_{Lcop_2}L+2b_{Kcop_2}K+\\
&\quad 2b_{Acop_2}A+2b_{Wcop_2}W\\
A_1 &= A-A_2
\end{aligned} \tag{10}$$

Regional dummy variables are incorporated in the final estimations to account for regional differences in agricultural production and land usage. A time trend to account for technology changes is also included. Expected prices, as defined above, replace market prices in the estimation process of the system in (10).

An important econometric issue underlies our empirical analysis: the stratified nature of the sample. We adopt the bootstrapping approach to deal with this problem. To obtain unbiased efficient estimates of the parameters of the model, we use a probability-weighted bootstrapping procedure, whereby the likelihood of being selected in any given replication is proportional to the number of farms in the population represented by each individual holding in the sample. Data are sampled with replacement.[16] The parameters are estimated for each pseudo sample of data. The parameters and their covariance matrices are derived from the distribution of the replicated estimates generated in the bootstrap process (parameters are given by the mean and their variances by the variances of the replicated estimates). As is the case for parameter estimates, the elasticities and their variances are derived from the replicated estimates generated in the bootstrap process.

Empirical Implementation

The empirical analysis focuses on the influence of agricultural policy measures on the use of plant protection products by a sample of French farms specialized in the production of COP. Farm-level data are taken from the Farm Accounting Data Network (FADN) for the period 1994-1999.[17] Hence, our period of analysis corresponds to the time during which the 1992 MacSharry reform was effective. Though the analysis is based on individual data, country aggregates are also used.

These aggregates are taken from Eurostat's New Cronos Database and the National Climatic Data Center (NCDC). While Eurostat provided price indices, the NCDC supplied us with weather statistics at the national level.

Using these sources, the variables used to estimate the model are constructed. Two variable inputs (crop protection products and other variable inputs) are distinguished. Other inputs consist of fertilizers, seeds, and planting materials; other crop-specific costs; energy; and other variable inputs. Input prices are not registered in FADN, instead national input price indices are taken from the Eurostat's New Cronos Database. Implicit quantity indices for variable inputs are derived by dividing the consumption of these inputs in currency units by their respective price indices. The price of other variable inputs is the numeraire in the normalized quadratic restricted profit function. In addition to the variable inputs, three quasi-fixed input categories are defined (labor, capital, and total land). Following our theoretical model, two output categories are distinguished (cereals; and oilseeds and protein crops). Prices for COP are approximated by using national price indices.[18] A variable representing the yearly mean temperature and regional dummy variables are also included as explanatory variables in the model. Summary statistics for the variables of interest are presented in table 1.

Results

Parameter estimates for equation (8) are statistically significant and have the expected sign (see table 2). These estimates can be used to predict the damage abatement (g_k) for crops 1 and 2, as well as to allocate total use of crop protection products among the two crops considered. Mean predicted values for these variables are presented in table 3. Predicted values for g_k indicate that crop damage is in the order of 7% for cereals and 6% for oilseeds and protein crops. The higher market value of oilseeds and protein crops relative to cereals may explain the differences in damage abatement.

Table 4 contains the parameter estimates for the system in (10). Expected prices for COP exert a positive influence on their respective production and acreage equations. This positive effect is, with the exception of the effect of p_2 on Y_2, statistically different from zero. The parameters representing cross-price effects are negative, thus suggesting that the two products considered are substitutes in production. Cross-price effects are statistically significant only in the hectare equations. As expected, compensatory payments also stimulate higher levels of production and land use. Parameters representing compensatory payments are positive and statistically significant. Consistently with cross-price effects, cross-payment effects are also negative and statistically significant.

Parameter estimates representing quasi-fixed inputs, which are all statistically significant, suggest a certain extensification in the production of oilseeds and protein crops, consisting of a reduction in labor and capital and an increase in total cultivated land. This extensification process may be a response to the reduction in market prices during the period of analysis. The variable representing weather conditions is only statistically different from zero in Y_2 equation and shows that higher temperatures contribute to attain higher production levels. Regional dummies, as expected, are very relevant in the understanding of both farmers' production and land use decisions.

Table 5 presents the mean long-run elasticity estimates. These elasticities suggest that both an increase in prices and compensatory payments for crop k generate a statistically significant increase in the usage of crop protection products. Perhaps of greater interest is the finding that price effects are always more elastic than the compensatory payment effects. Hence, one could say that, after the 1992 reform, the CAP became more environmentally friendly because the reductions in price-support measures in favor of compensatory payments stimulated a more precise application of crop protection products. This allows us to conclude that such a policy reform involves a certain degree of policy decoupling. However, compensatory payments, though less distorting than price supports, continue to influence decisions of economic agents. Consistent with cross-price and cross-payments effects (table 5), cross-price and cross-payments elasticities are negative and mostly statistically significant.

Our model estimation provides a framework to study the effects of changes in prices and compensatory payments on the use of crop protection products. In a simulation exercise, we study the effects of shocking the model with a 15% decrease in cereal prices and an equivalent increase in compensatory payments. The farm-level predicted values are recalculated under the new scenario, and mean values of these predictions are presented in table 6. The same process is repeated for oilseeds and protein crops and for shocks to both crop categories at the same time. Our simulations forecast that when cereal prices and compensatory payments are shocked, the consumption of crop protection products for cereals declines by a 6%. This reduction implies an increase in crop damage from 6 to 7%.[19] Output decreases by almost 3%, and hectares remain mostly unchanged. Table 6 also indicates that the effects on the oilseed and protein crop sector of reducing cereal prices and increasing their compensatory payments by 15% are negligible. Total crop protection products usage ($Z = Z_1 + Z_2$) decreases by 5% under this scenario.

A drop in the price of oilseeds and protein crops by 15% and an increase in payments of the same amount implies a reduction in the order of 3% in crop protection products usage on these crops. The lower reduction in the consumption of crop protection products compared to cereals may be attributed to the higher market price for oilseeds and protein crops. Production, however, experiments a decline of almost 9%, and the hectares planted decrease by 6%. Another response generated by the decrease in the oilseeds and protein crop prices is the increase in cereal production of about 2.5%. This increase in cereal production raises Z_1 above the base scenario, resulting in a minor increase in the total usage of crop protection products ($Z = Z_1 + Z_2$).

When shocks in price and compensatory payments affect both crop categories, the results indicate a reduction in total usage of crop protection products in the order of 4.5%. Farmers cut the crop protection products usage on cereals by a 5% and by almost 3% for oilseeds and protein crops. Confirming the results of previous simulations, a price cut has a higher restructuring effect on the oilseed and protein crop sector than in the cereal sector: the production of oilseeds and protein crops experiences an 8% decline as a response to the shocks, while cereal production remains almost constant. Damage abatement levels stay stable for oilseeds and protein crops and suffer a slight decline in the cereal sector.

Concluding Remarks

We analyze the extent to which the 1992 CAP reforms contributed to a reduction in the consumption of crop protection products registered in the E.U. in the 1990s. These reforms mainly consisted of a reduction in price-support measures in favor of direct compensatory payments to farmers. We hypothesize that, to the extent that the MacSharry reforms could have stimulated a more precise application of agricultural inputs and management techniques, the post 1992 CAP could have had a positive environmental impact, by stimulating a reduction in usage of crop protection products.

We concentrate on the cereal, oilseed, and protein crop sector in which the 1992 CAP reforms made a special emphasis. Our empirical application uses farm-level data for a sample of French farms specialized in the production of the cited crops, observed from 1994 to 1999.

In order to assess the influence of the COP regime on the consumption of crop protection products, we adopt the multi-output generalization of the Lichtenberg-Zilberman damage control technology model developed by Chambers and Lichtenberg. We extend this model to provide a method to allocate the consumption of crop protection products among crops.

Results suggest that both an increase in prices and compensatory payments generate a statistically significant rise in the usage of crop protection products. Perhaps of greater interest is the finding that the price effects are always more elastic than the compensatory payment effects. This result suggests that a policy reform consisting of a reduction in price-support measures compensated by direct payments to farmers, such as the 1992 CAP reform, involves a certain degree of agricultural policy decoupling and may result in a reduction in the use of crop protection products. However, compensatory payments, though less distorting than price supports, continue to influence the production decisions taken by economic agents.

Our estimations provide a framework to predict the effects of changes in prices and compensatory payments on the use of crop protection products. Simulations are conducted to forecast the effects of shocks to both variables. Results show that a reduction in prices compensated by an increase in direct payments causes a reduction in the use of crop protection products that is higher, the lower the market value for the crop. These simulations also show the importance of accounting for cross-price and cross-payment effects in predicting the policy reform effects on total consumption of crop protection products.

Footnotes

[1] On the theoretical front, Just and Antle developed a conceptual model to study the interactions between the agricultural and environmental policies and pollution. On the empirical side, several analyses have studied the relationship between agricultural policy and environmental degradation from a global perspective (see Anderson) and both in the U.S. (see, for example, Horowitz and Lichtenberg; and Smith and Goodwin) and in Europe (see Hanley; Abler and Shortle; Liapis; and Winter and Gaskell for some examples).

[2] The conventional approach to determining the output effects of farm policy measures has assumed perfect markets, constant returns to scale and risk neutral producers. Under this framework, only those policies that alter relative market prices have been found to impact on farmers' decisions. However, one should take into account that the economic literature has also shown that when markets are imperfect, returns to scale are other than constant and producers are not risk neutral, lump sum transfers could have production implications (Hennessy; Phimister; Rude).

[3] Institutional prices for oilseeds had been abolished with the reform of the oilseed sector one year before the overall 1992 CAP reforms.

[4] It was established that compensatory payments for oilseeds would be partially adjusted according to the evolution of market prices.

[5] Professional producers were defined as those with an extension of land capable of growing more than 92 tons of cereals.

[6] Up until the 1995/96 marketing year, the set-aside rate was differentiated between rotational and non-rotational set asides. However, from 1996-97 and on, a single rate was introduced. Farmers may use the set-aside land to grow non-food crops and still receive compensation.

[7] Subject to the limitations mentioned above, the per-hectare payments received by farmers are based on producers' annual acreage declarations.

[8] A single exception is land allocation. Just, Zilberman, and Hochman note that if data on input allocations are not available, technological relationships cannot be estimated without the adoption of assumptions that restrict either behavior or technology. These authors also note that increased efficiency in estimating production parameters can be achieved when reasonable behavioral assumptions are made.

[9] We impose constant returns to scale in crop protection products.

[10] This implies the assumption that $\pi(\mathbf{p}, w, \mathbf{cop}, v, L, K, A, W)$ is conditionally additive in v and $(\mathbf{p}, w, \mathbf{cop}, L, K, A, W)$.

[11] Recall that the intervention prices for oilseeds and protein crops were eliminated.

[12] Other price specifications, such as the Chavas and Holt proposal, were considered, but they yielded lower quality results.

[15] While other specifications were also considered, such as adaptive expectations (Chavas and Holt; Pope and Just), less consistent results were derived.

[14] Due to the fact that our database is an incomplete panel, individual lagged prices and yields cannot be constructed without losing a very significant number of observations. To avoid this problem, national averages are used instead.

[15] Prices and compensatory payments are normalized using variable input prices.

[16] We utilize 500 replications. The number of replications is limited due to the computer-intensive nature of the probability-weighted sampling.

[17] Retrospective data for the period 1992-1993 are used to compute the value of lagged variables used in the analysis.

[18] An index for intervention prices is also constructed in order to be able to define the expected prices as outlined above. The FADN database does not explicitly register output prices. However, other alternatives such as approximating prices through dividing the value of total output in currency units by the total production in tons were also tried, but yielded results not compatible with economic theory. A feasible explanation for this problem may be the incomplete panel nature of the FADN database, which implies that the farms that integrate the sample in year *t* will not necessarily remain in FADN in year *t+1*. Given this fact, the actual prices perceived by the sample farms last year (recall that lagged prices are used in the formation of price expectations), may not necessarily be a good indicator of the price expectations of sample farms in period *t*. Changes in the composition of crop mix from year to year may also play a role in complicating the identification of price effects when these prices are used.

[19] We tested for the difference between these two mean predicted values. Results indicate that the two values are not statistically different. Details of the test are available from the authors upon request.

References

Abler, D.G., and J. S. Shortle. "Potential for Environmental and Agricultural Policy Linkages and Reforms in the European Community." *American Journal of Agricultural Economics* 74(August 1992):775-781.

Anderson, K. "Agricultural Trade Liberalization and the Environment: A Global Perspective." *World Economy* 15(January 1992):153-171.

Antle, J.M., and R.E. Just. "Effects of Commodity Program Structure on Resource Use and the Environment." *Commodity and Resource Policies in Agricultural Systems*. R. Just, and N. Bockstael, eds., pp. 97-127, New York: Springer-Verlag, 1991.

Babcock, B., E. Lichtenberg, and D. Zilberman. "Impact of Damage Control and Quality of Output: Estimating Pest Control Effectiveness." *American Journal of Agricultural Economics* 74(February 1992):163-172.

Boatman, N., C. Stoate, C. Rio Carvalho, R. Borralho, G. de Snoo, and P. Eden "The Environmental Impact of Arable Crop Production in the European Union: Practical Options for Improvement." A report prepared for Directorate-General XI of the European Commission, 1999.

Chambers, R.G. "The Incidence of Agricultural Policies." *Journal of Public Economics* 57(June 1995):317-335.

Chambers, R.G., and E. Lichtenberg. "Simple Econometrics of Pesticide Productivity." *American Journal of Agricultural Economics* 76(August 1994):407-417.

Chavas, J.P., and M. T. Holt. "Acreage Decisions Under Risk: The Case of Corn and Soybeans." *American Journal of Agricultural Economics* 72(August 1990):529-538.

Commission of the European Communities. "Directions towards Sustainable Agriculture." Communication from the Commission to the Council; The European Parliament; the

Economic and Social Committee; and the Committee of the Regions. COM (1999) 22 final, Brussels, 1999.

Gardner, B.L. "Changing Economic Perspectives on the Farm Problem." *Journal of Economic Literature* 30(March 1992):62-101.

Gardner, B.L. *American Agriculture in the Twentieth Century: How it Flourished and What it Cost.* London: Harvard University Press, 2002.

Guyomard, H., M. Baundry, and A. Carpentier. "Estimating Crop Supply Response in the Presence of Farm Programmes: Application to the CAP." *European Review of Agricultural Economics* 23(1996):401-420.

Hanley, N. "The Economics of Nitrate Pollution." *European Review of Agricultural Economics* 17(1990):129-151.

Hennessy, D.A. "The Production Effects of Agricultural Income Support Policies Under Uncertainty." *American Journal of Agricultural Economics* 80(February 1998):46-57.

Horowitz, J.K., and E. Lichtenberg. "Insurance, Moral Hazard, and Chemical Use in Agriculture." *American Journal of Agricultural Economics* 75(November 1993):926-935.

Just, R.E., and J.M. Antle. "Interactions Between Agricultural and Environmental Policies: a Conceptual Framework." *American Economic Review* 80(May 1990):197-202.

Just, R.E., D. Zilberman, and E. Hochman. "Estimation of Multicrop Production Functions." *American Journal of Agricultural Economics* 65(November 1983):770-780.

Just, R.E., D. Zilberman, E. Hochman, and Z. Bar-Shira. "Input Allocation in Multicrop Systems." *American Journal of Agricultural Economics* 72(February 1990):200-220.

Liapis, P.S. "Environmental and Economic Implications of Alternative EC Policies." *Journal of Agricultural and Applied Economics* 26(July 1994):241-251.

Lichtenberg, E., and D. Zilberman. "The Econometrics of Damage Control: Why Specification Matters." *American Journal of Agricultural Economics* 68(May 1986):261-273.

Moro, D., and P. Sckokai. "Modelling the CAP Arable Crop Regime in Italy: Degree of Decoupling and Impact of Agenda 2000." *Cahiers d'Economie at Sociologie Rurales* 53(1999):49-73.

Oude Lansink, A., and J. Peerlings. "Modelling the New EU Cereals Regime in the Netherlands." *European Review of Agricultural Economics* 23(1996):161-178.

Pope, R.D., and R.E. Just. "On Testing the Structure of Risk Preferences in Agricultural Supply Analysis." *American Journal of Agricultural Economics* 73(August 1991):743-748.

Phimister, E. "Farm Household Production in the Presence of Restrictions on Debt: Theory and Policy Implications." *Journal of Agricultural Economics* 46(September 1995):371-380.

Rude, J.I. "Under the Green Box. The WTO and Farm Subsidies." *Journal of World Trade* 35(October 2001):1015-1033.

Skea, A. "The Effects of CAP Reform on Scottish Faming." *Scottish Agricultural Economics Review* 7(September 1993):1-14.

Smith, V.H., and B.K. Goodwin. "Crop Insurance, Moral Hazard, and Agricultural Chemical Use." *American Journal of Agricultural Economics* 78(May 1996):428-438.

Williamson, O. "The Politics and Economics of Redistribution and Inefficiency." *The Mechanisms of Governance*. Williamson, O, ed., pp. 195-213. Oxford: Oxford University Press, 1996.

Winter, M., and P. Gaskell. "The Agenda 2000 Debate and CAP Reform in Great Britain. Is the Environment Being Sidelined?" *Land Use Policy* 15(July 1998):217-231.

Table1. Summary Statistics for the Variables of Interest

	Mean / (Standard Deviation) (n=8137)
Y_1 (cereal production) francs	606521.13 (454375.19)
Y_2 (oilseed and protein crop production) francs	206320.01 (198396.36)
A_1 (land planted to cereals) hectares	73.84 (46.87)
A_2 (land planted to oilseeds and protein crops) hectares	28.84 (25.67)
A (total land) hectares	102.68 (64.55)
w (price of variable inputs) index	1.05 (0.03)
p_1 =max($p_{1,t-1}$, guaranteed price) (expected price for cereals) index	0.73 (0.07)
p_2 = $p_{2,t-1}$ (expected price for oilseeds and protein crops) index	0.55 (0.03)
cop_1 (compensatory payments to cereals) francs/hectare	2878.95 (679.99)
cop_2 (compensatory payments to oilseeds and protein crops) francs/hectare	5266.67 (2205.79)
L (labor) annual working units	1.48 (0.67)
K (capital) francs	563754.97 (489534.92)
W (annual mean temperature) 1/10 Celsius degrees	117.61 (5.28)
v (price of crop protection products) index	0.99 (0.02)
Z (consumption of crop protection products) francs	95360.13 (67364.09)

Note: all monetary values are expressed in constant 1990 currency units

Table 2. Parameter Estimates and Summary Statistics for the Crop Protection Products Demand Function

Coefficient / (Standard Error)	
λ_1	0.00287* (0.00007)
λ_2	0.00406* (0.00028)

Note: An asterisk (*) denotes statistical significance at the α = 0.05 level.

Table 3. Mean Predicted Values for g_1, g_2, Z_1, and Z_2

Coefficient / (Standard Error)	
g_1 (damage abatement for cereals)	0.93 (0.06)
Z_1 (total application of crop protection products to cereals)	74917.75 (48299.93)
g_2 (damage abatement for oilseeds and protein crops)	0.94 (0.01)
Z_2 (total application of crop protection products to oilseeds and protein crops)	19672.72 (17620.06)

Table 4. Parameter Estimates and Summary Statistics for the System of Equations

	Coefficient / (Standard Error)		
	Y_1 (cereal production)	Y_2 (oilseed and protein crop production)	A_2 (land planted to oilseeds and protein crops)
Intercept	-561734.09200* (73826.47174)	-58359.33570 (35351.34860)	-4.11537 (4.72256)
p_1 (expected prices for cereals)	265989.43620* (49792.72064)	-38975.50640 (24756.93044)	-6.23871* (3.19354)
p_2 (expected prices for oilseeds and protein crops)	-63786.15310 (66004.34396)	34611.18632 (30387.69392)	14.73116* (3.68237)
cop_1 (compensatory payments to cereals)	45.52405* (2.47741)	-7.77001* (0.86844)	-0.00151* (0.00014)
cop_2 (compensatory payments to oilseeds and protein crops)	-6.65601* (0.80871)	4.38869* (0.32547)	0.00070* (0.00005)
L (labor)	25166.46911* (3651.64582)	-6665.88925* (1444.77224)	-1.03204* (0.19277)
K (capital)	0.07370* (0.00623)	-0.01222* (0.00325)	-0.00000* (0.00000)
A (total land)	2678.42925* (99.92993)	1122.68260* (38.88260)	0.16217* (0.00513)
W (annual mean temperature)	-300.96587 (291.74524)	351.94313* (123.91146)	-0.00939 (0.01612)
T (time trend)	7566.29769* (2035.64993)	1573.43023 (1006.46803)	-0.04002 (0.12992)
REGIONAL DUMMY1	-33031.90819* (4753.85223)	2498.36477 (3193.40291)	1.30654* (0.32726)
REGIONAL DUMMY2	-1102.91148 (4985.13571)	-8604.89633* (3655.00578)	-0.55595 (0.38022)
REGIONAL DUMMY3	-15504.09712 (5531.12758*)	24333.77148* (5385.36706)	1.99775* (0.43660)
REGIONAL DUMMY4	-3316.64809 (4434.34912)	-8438.17807* (3038.72994)	0.89568* (0.30635)
REGIONAL DUMMY5	-9878.07128 (6403.47428)	9477.15241 (4921.98801)	0.95188* (0.47074)
REGIONAL DUMMY6	-62729.75334 (5216.79584)*	3347.57828 (3601.36254)	2.53499* (0.36669)
REGIONAL DUMMY7	-12696.95378 (7527.72565)	-1214.93200 (4163.86906)	1.05628* (0.47786)
REGIONAL DUMMY8	-82478.08109* (7776.22496)	23714.96912* (5048.16513)	3.89054* (0.54509)
REGIONAL DUMMY9	74622.93918* (8551.69710)	-18168.23620* (4107.22680)	-0.14156 (0.50029)
REGIONAL DUMMY10	-39456.12705* (9508.02063)	-7805.82833 (7032.82130)	2.55508* (0.79585)
REGIONAL DUMMY11	23143.39313* (7884.18531)	-17861.88451* (4053.43702)	0.25922 (0.48742)

Note: An asterisk (*) denotes statistical significance at the α = 0.05 level.

Table 4. Parameter Estimates and Summary Statistics for the System of Equations (continued)

	Coefficient / (Standard Error)		
	Y_1 (cereal production)	Y_2 (oilseed and protein crop production)	A_2 (land planted to oilseeds and protein crops)
REGIONAL DUMMY12	-21407.99493* (7484.56386)	-17810.79782* (4118.83375)	0.13087 (0.46981)
REGIONAL DUMMY13	-10648.75836 (5615.93316)	-15721.41637* (3194.45022)	2.36842* (0.36236)
REGIONAL DUMMY14	20679.77586 (11231.64382)	-13510.77096* (4729.94458)	1.24412* (0.60396)
REGIONAL DUMMY15	-37154.38425* (6606.92903)	-3195.88501 (3346.47606)	4.98491* (0.40122)
REGIONAL DUMMY16	38508.90278* (7226.55743)	-22094.40912* (4023.43918)	-0.35126 (0.45522)
REGIONAL DUMMY17	45637.79699* (11247.89083)	-27270.34367* (4485.78919)	-0.65337 (0.57672)
REGIONAL DUMMY18	-116755.15930* (10085.75110)	-16191.44858* (4896.26191)	4.04315* (0.66551)
REGIONAL DUMMY19	-84272.94874* (18118.70206)	-3837.58097 (6722.31267)	3.68937* (0.95831)

Note: An asterisk (*) denotes statistical significance at the α = 0.05 level.

Table 5. Mean Elasticity Estimates and Summary Statistics

Coefficient / (Standard Error)	
$\varepsilon_{Z1_{COP1}}$	0.35858* (0.02223)
$\varepsilon_{Z1_{COP2}}$	-0.11060* (0.00944)
$\varepsilon_{Z2_{COP1}}$	-0.39328* (0.04400)
$\varepsilon_{Z2_{COP2}}$	0.37923* (0.02970)
$\varepsilon_{Z1_{P1}}$	0.89452* (0.12417)
$\varepsilon_{Z2_{P1}}$	-0.43794 (0.23601)
$\varepsilon_{Z1_{P2}}$	-0.28092* (0.11669)
$\varepsilon_{Z2_{P2}}$	0.87406* (0.20969)

Note: An asterisk (*) denotes statistical significance at the α = 0.05 level

Table 6. Simulations: Mean of the Simulation Results

	Base scenario (predicted values of the model)	15% decrease in p_1 15% increase in cop_1		15% decrease in p_2 15% increase in cop_2		15% decrease in p_1 and p_2 15% increase in cop_1 and cop_2	
	Values	**Values**	**% change**	**Values**	**% change**	**Values**	**% change**
Z_1 (total application of crop protection products to cereals)	75297.45466	70637.31408	-6.19	76151.83193	1.13	71519.75928	-5.02
Z_2 (total application of crop protection products to oilseeds and protein crops)	21275.42420	21362.40298	0.41	20626.17823	-3.05	20687.85770	-2.76
Z_1 + Z_2	96572.87886	91999.71705	-4.74	96778.01017	0.21	92207.61698	-4.52
Y_1 (cereal production)	616685.81986	599884.87422	-2.72	631956.28472	2.48	615169.32290	-0.25
Y_2 (oilseed and protein crop production)	218094.90718	219543.55237	0.66	198750.95498	-8.87	200086.74960	-8.26
A_1 (land planted to cereals)	74.00471	73.93322	-0.10	74.45612	0.61	74.38463	0.51
A_2 (land planted to oilseeds and protein crops)	30.34559	30.42866	0.27	28.43781	-6.29	28.53407	-5.97
g_1 (damage abatement for cereals)	0.94169	0.92726	-1.53	0.94425	0.27	0.93135	-1.10
g_2 (damage abatement for oilseeds and protein crops)	0.93757	0.93820	0.07	0.93802	0.05	0.938875	0.14