# Policy Scenarios with the CARD LP Model

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## Introduction

These materials have been assembled to support the presentation of the results for the nitrogen tax and CRP policy scenarios at the AAEA preconference workshop. Summary results from the analyses have been prepared and included in the document distributed to symposium participants. But, the process of adapting the scenario specifications to the CARD LP model was complex and involved additional specializing assumptions. These assumptions and in general, the approach used to prepare the model for analysis of the scenarios are discussed in the next section on policy implementation.

Documentation for the CARD LP system is provided in the section following the discussion of implementation. This documentation provides an overview of the model structure. Data sources for the major components of the model are discussed as well. The CARD LP model requires a substantial amount of information generated externally. Examples include technology, exports, and domestic consumption demand. Procedures for generating this conditioning data are reviewed in the documentation overview as well.

The LP model is large scale with many regions, crops, land classes, and other dimensions. Thus, output from the policy scenarios is extensive. To illustrate the nature of the output and to enrich the discussion of the policy scenario results, a sampling of these summary tables is provided. These tables are for the Corn-Belt and for the nation.

For the presentation, transparencies were prepared. Copies of these summary transparencies are included in the last section. They lay-out the dimensions of the model, the results for the scenarios, and the model structure.

## Policy Implementation in the CARD LP

The nature of the CARD LP combined with the characteristics of the CRP and nitrogen tax policy scenarios dictate a need for special assumptions in implementing the policy analysis. The CARD LP has a cost minimization rather than a profit maximization criterion. Both of these policies involve profit considerations. The cost minimization and the profit maximization criterion may give different outcomes except for special long run competitive equilibrium environments which differ from both of these policy scenarios. In addition, in the cost minimization case commodity prices and resource rents are determined endogenously and are not available for a priori policy specification of the model.

The policy provisions of both the nitrogen tax and the CRP policies are more broadbased than the disaggregated resource and technology detail included in the LP. Therefore, assumptions for disaggregating the policy provisions to match the LP dimensions are required.

The procedures used to set the LP up to evaluate these two policies are discussed briefly below. First, the nitrogen tax policy and then the CRP policy implementation procedures are briefly outlined.

### Implementing the Five Cent Nitrogen Tax in the CARD LP

A discussion of yield determination in the CARD LP is essential before the implementation of the nitrogen tax can be considered. For a given area, land quality and a set of management strategies, the crop yields of each cropping activity are fixed as are the fertilizer requirements. Solution yield and fertilizer levels can only change as activity levels change. The yield levels represent 1990 technology while

the fertilizer coefficients are derived as explained below. There are several steps in determining 1990 yield levels. First, 1985-86 average yield levels by PA are determined using county-level USDA survey data. Then, as explained in the CARD LP documentation, indices for land group, crop sequence, accumulated erosion, tillage method, conservation practice, and irrigation are applied to the average area yield to estimate the yield for a particular model activity.

For each cropping activity in the CARD LP yields of individual crops are determined by applying the appropriate set of management indices to a base yield as explained above. A Spillman-type yield function is then solved backward to determine fertilizer requirements. Nitrogen phosphorous and potassium are applied in fixed proportions according to the Spillman coefficients regardless of yield levels. The functional form used for yields is show in (1) with the optimal fertilizer unit defined by (2).

$$Y(t) = Y_0(t) + A * (1 - 0.8^{X(t)}) * PF(t) \qquad (1)$$

where:

A is the maximum potential yield response to fertilization; Y(t) is the estimated average yield per planted acre of the crop in year (t); $Y_0(t)$ is the estimated average yield per planted acre on unfertilized land in year (t) and developed from a linear trend function; X(t) is the number of units of fertilizer applied to each acre of the crop year (t); PF(t) is the proportion of the acreage of the crop receiving fertilizer in the year (t) and developed from a linear

trend of the proportion of the crop acres receiving fertilizer; and t is the years after 1949.

The X(t) defined above represents:

$$X(t) = PO_t \{\ln (P_x/P_c) - \ln A - [\ln (-\ln 0.8P]\}/\ln 0.8 \qquad (2)$$

where:

ln is the natural log of base e; $P_x$ is the weighted price of a unit of fertilizer; $P_c$ is the price of a unit of crop (c); and PO is the proportion of the optimum rate of fertilizer applied in year (t), developed from a linear trend of the proportion of the optimum rates applied; and t is the years after 1964.

State level coefficients for (1) and (2) were estimated in 1974 by Stoecker for major field crops using data collected by Ibach and Adams (1967). These state-level coefficients were weighted to PAs using crop acreage data from the 1974 Census of Agriculture (English et al., 1982). Some extrapolations were used to expand the coefficient set to cover the full set of crops included in the current CARD LP. Crop and fertilizer prices of 1980 are used and the proportional trend coefficients are truncated at 1.0 for the current model.

For the five cent nitrogen tax scenario, the price of nitrogen was increased by five cents for equation (2). The new fertilizer application coming from (2) was then compared to the original to estimate a proportionate change in nitrogen, phosphorous, and potassium. The new fertilizer level was included in (1) and the resulting yield compared to the original. These proportionate changes in nitrogen, phosphorous, potassium, and yields were applied to the original model coefficients with

one exception. Where nitrogen carryover from legume crops in the rotation was large enough that a proportionate reduction in total nitrogen requirement would result in a net after carryover requirement of less than zero, the new nitrogen requirement was set at zero.

**Implementing the 65 Million Acre CRP in the CARD LP**

The CARD LP has little economic freedom for choosing where CRP land is to be enrolled. The LP may choose for a given PA and soil type whether the CRP land will come out of dry, surface water irrigated, or groundwater irrigated land. Allocations of CRP land by PA and land group are determined by a related system of models where the historical CRP sign-up pattern, distribution of CRP eligible land, and distribution of CRP eligible-allocatable land are considered. Incorporating these considerations directly in the CARD LP would involve a prohibitively large constraint set.

The historical CRP sign-up pattern matches neither the distribution of CRP eligible land nor the distribution of least productive land as determined by the CARD LP. These variances are due to economic factors--the comparison of profits from continued cropping with the CRP rental rate. Due to farm program subsidies and other factors, this profit and CRP rental comparison does not match that implied by the national cost minimization criterion of the CARD LP. There are also program parameters which encourage continued cropping of the less productive land in some regions. That is, the historical CRP sign-up had to be exogenously imposed.

The eligibility and allocatability criterion arise both from CRP program parameters and maintained model assumptions. The eligibility characteristics are based on erosion rather than productivity. In the CARD LP the proportions of land in soil types 2 through 8 meeting the eligibility criterion are determined based on the 1982 Natural Resources Inventory.

A quadratic programming model containing the historical CRP sign-up, the county maximum sign-ups, and the net-after-LP model constraints available land base was formulated to determine the CRP enrollments by county and land group. This model has for choice variables CRP sign-up levels by county and land group. The optimization criterion was a weighted minimization, involving deviations from post sign-ups and an equalizing of proportions of eligible CRP areas signed-up among counties. The county and land group enrollments from this model were then aggregated to PA land group levels.

## References

Ibach, D.B. and J.B. Adams. 1967. Fertilizer Use in the United States by Crops and Areas, 1964, Estimates. Economic Research Service and Statistical Reporting Service, USDA, Statistical Bulletin No. 408, August. Government Printing Office, Washington, D.C.

Stoecker, Art. 1974. A Quadratic Programming Model of U.S. Agriculture in 1980: Theory and Application. Unpublished Ph.D. dissertation, Iowa State University, Ames, Iowa.

English, Burton C., Klaus F. Alt, and Earl O. Heady. 1982. A Documentation of the Resources Conservation Act's Assessment Model of Regional Agricultural Production, Land and Water Use, and Soil Loss. CARD Report 107T, Center for Agricultural and Rural Development, Iowa State University, Ames.

## CARD LP Documentation Overview

The report to follow is by English, Smith, and Oamek. It was prepared for the documentation of the system used for the RCA analysis. The modeling system employed for the exercises is essentially the same as is described in this documentation.