Analysis of Agricultural Economics for the Central Valley Project Improvement Act Programmatic Environmental Impact Statement

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Abstract

Section 3409 of the Central Valley Project Improvement Act requires a Programmatic Environmental Impact Statement of the Act. The CVPIA may affect Central Valley agriculture in many ways. This paper describes the analysis of agricultural economics for the PEIS with emphasis on the Central Valley Production Model.

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Introduction

Section 3409 of the Central Valley Project Improvement Act (CVPIA) requires a Programmatic Environmental Impact Statement (PEIS) of the Act. The CVPIA may affect agriculture in California's Central Valley through:

- The dedication of 800,000 acre-feet (af) of Central Valley Project (CVP) project yield for fish, wildlife and habitat restoration, and re-allocation of additional CVP supplies for wildlife refuges and Trinity River flows;
- Increased CVP water prices in the form of mitigation and restoration payments, and tiered water pricing;
- Establishment of a Restoration Fund used to acquire water for fish and wildlife from willing sellers throughout the Central Valley;
- Water transfer provisions which allow CVP contract water to be sold to non-CVP entities;
- Other provisions involving water conservation, contract renewals, water banking, land retirement, and habitat restoration.

The analysis of agricultural economics for the PEIS uses the Central Valley Production Model (CVPM) to estimate direct economic impacts and costs to agriculture. This paper describes the CVPM and explains how it has been used in the PEIS. Technical details of the CVPM and data used in the analysis will be made available, and results will be presented at the WAEA 1997 meetings.

Description of the Central Valley Production Model

The Central Valley Production Model (CVPM) is a multi-regional model of irrigated agricultural production and economics that simulates the decisions of agricultural producers in the Central Valley. The model is based on an optimization technique known as Positive Mathematical Programming (PMP). Several models of California agriculture based on PMP have contributed to the theory and application of the CVPM. These precursors have been used to estimate field crop losses caused by air pollution (Howitt, 1989) and drought (Howitt, 1994), demand functions for water (Howitt, 1983), inter-regional water transfers (Vaux and Howitt, 1984), impacts of changes in water supplies (Farnam, 1994), and impacts of drainage control policies (Hatchett et al., 1991; Dinar et al., 1991).

The model can include 22 crop production regions, all in the Central Valley, and 26 categories of crops. To obtain a market solution, the model's objective function maximizes the sum of producer and consumer surplus, subject to the following model components:

- Linear marginal cost functions. The PMP technique is used to calibrate coefficients of the linear marginal cost function so that the calibration period crop acreage will be duplicated as a result of the model if no other input data are changed.
- Acreage response elasticities, estimated with econometric methods or obtained from secondary sources, are used in the calibration by being incorporated into the linear marginal cost functions.
- Commodity demand functions relate market price to Central Valley production. Price flexibilities were derived from State estimates and information on the share of each commodity grown in the Central Valley.
- Isoquants describe the trade-off between applied water and irrigation technology. Data on irrigation system cost and applied water efficiency were used to develop the isoquants. Both applied water and irrigation system cost are endogenous variables. The constant elasticity of substitution isoquants act as nonlinear constraints in the optimization.
- a variety of constraints involving land and water availability, and other legal, physical and economic limitations; especially crop production costs. The CVPM includes irrigation system costs, water costs, other fixed costs, harvest costs as a function of yield, and other variable costs as distinct cost categories.

Positive Mathematical Programming

A detailed description of PMP appears in Howitt (1995). PMP incorporates both marginal and average conditions into an optimization model by augmenting the linear total cost (or revenue) function with quadratic terms that guarantee that marginal cost will equal price at the observed crop mix. The objective of the standard programming approach is to maximize net revenue, defined as:

1) $NR = (py - AC) \cdot X$

where p is a vector of prices per unit, y is a vector of yield in units per acre, AC is a vector of average production costs per acre, and X is a vector of acres. This expresses net revenue in terms of average revenues and costs. PMP augments this linear specification with a nonlinear function of acreage by crop, f(X):

2) $NR = (py - AC) \cdot X + f(X)$

In the CVPM, the nonlinear function is quadratic. Calculated properly, the augmented, nonlinear objective function will produce the same level of net revenue as the linear function at the baseline acreage, but it can also create marginal conditions that satisfy profit-maximizing first order conditions at the baseline acreage. The PMP procedure is mathematically equivalent to adding a nonlinear adjustment cost function onto the linear NR specification, although the rationale and interpretation are quite different.

Other Features

Long-run and short-run versions of the model were developed to consider long-run response under average hydrologic conditions, and short-run response during drought. The long-run analysis limits perennial acreage to levels that can be supported during drought, and water use required for non-bearing perennial acreage is included in the long-run analysis to account for the average replacement rate of these crops. Irrigation technology is held constant in the short run. The model includes farm program payments for corn, rice, other grains, and cotton according to the provisions in place in 1992. These payments are lost if land is permanently retired, but they are not lost by land fallow during drought.

The model differentiates five categories of water, each having different costs in each region; CVP contract water, CVP water rights and exchange water, State Water Project water, local surface water, and groundwater. In the analysis, surface water supplies are estimated by hydrologic models, and groundwater use and pumping lift are estimated iteratively with a groundwater simulation model (see **Effects on Water Supplies** below). Water costs include a project charge (the wholesale rate) and a district charge (the retail margin).

The model uses County Agricultural Commissioner (CAC) reports as the basis for its recent land use database. However, the CACs generally report all harvested acreage while the CVPM requires irrigated acreage and harvested irrigated acreage. Data from the 1987 and 1992 U.S. Agricultural Census were used to estimate dryland acreage and non-harvested irrigated acreage, and the necessary irrigated acreage estimates were derived.

Evaluation of the CVPM

The CVPM has been tested by using it to backcast real situations. To see if the model could predict irrigated acreage during water-short conditions, the CVPM was tested by comparing its estimates of land use for 1991 and 1992 to actual data. Data from preceding years were used for calibration, but the test included 1991 and 1992 surface water supplies, expected crop prices, and acreage reduction percents and deficiency payments for program crops. In addition, acreage trends were estimated from the full 10 years of data and used to account for demand shifts. An 11-region aggregation of CVPM with 12 crop groups was used, and the model was run as a short-run analysis.

For every crop group but one, the predicted direction of change from the base acreage was the same as the actual. The exception was an actual drop in grape acreage which was not predicted by the CVPM. The difference between the predicted and actual acreage, as a percent of actual, was less than 10 percent for 9 out of 12 crop groups.

In another test, the version of the model with water transfers was used to mimic the State’s 1991 Drought Water Bank (See **Water Transfers** below). In 1991, the State offered $125 per acre-foot at the Delta for water made available from land fallow. This offer was represented in a 1991 version of the CVPM as a very elastic demand at $125. The simulation closely approximated actual total purchases and the distribution of purchases across selling regions..

PEIS Alternatives and Analysis

The PEIS is evaluating five alternatives; the No-Action Alternative and four Action Alternatives. The No-Action Alternative describes the without-CVPIA baseline condition. A 2020 development condition is assumed. Baseline acreage and crop mix are based on 2020 projections and assumptions provided by the California Department of Water Resources (DWR, 1994). CVPM demand and supply functions are shifted to reproduce 2020 acreage while preserving current real crop prices and elasticities. Next, the No-Action agricultural analysis estimates how acreage, production, and water use might change from DWR's baseline in response to PEIS No-Action water supply conditions. This analysis is used as a basis for comparison with the Action alternatives.

The No-Action analysis uses cost-of-service water prices shown in Reclamation's 1993 and 1994 water rate manual (Reclamation, 1993, 1994). This rate is set to recover current costs of operation and maintenance (O&M), accumulated O&M deficit, and principal only on allocated capital costs. The analysis assumes that the current ability-to-pay policy remains in effect, and appropriate water rates are estimated using payment capacities from a 1992 planning-level study prepared by Reclamation (1992). The analysis of hydrology and water deliveries incorporates the Delta operations of the 1994 Bay-Delta Accord which limits Delta exports and requires a ratio of Delta inflow to exports during most conditions.

The PEIS includes four Action alternatives. All Action alternatives include the non-discretionary provisions of the CVPIA, but there are important differences in how money and water are managed for fish and wildlife purposes. In Alternative 1, none of the Restoration Fund is spent for water acquisition. Some of the 800,000 af of water dedicated for fish and wildlife is used for instream flows and becomes available for export to water users south of the Delta. Alternative 2 adds priority water acquisition for fish and wildlife habitat, and acquisitions are increased in Alternatives 3 and 4. Alternative 3 allows for more export of dedicated or acquired water, but Alternative 4 allows for no export of dedicated or acquired water. All acquisitions are from willing agricultural sellers.

Application of the CVPM to PEIS Issues

Effects on Water Supplies. CVPM water supplies are linked to surface water and groundwater models. PROSIM, a surface water and water delivery simulation model maintained by Reclamation, is used to estimate most CVP and SWP water deliveries, Delta exports, and river flows in and north of the Delta. SANJASM is used to estimate surface water flows and deliveries in the San Joaquin Valley. The Central Valley

Groundwater/Surface Water Model (CVGSM) is used, with the CVPM, to estimate non-project surface supply and groundwater pumping and depth. The CVPM accepts initial calculations of surface water deliveries and estimates crop mix, irrigation efficiency, and amount of groundwater pumping based on economics. The CVGSM accepts this revised crop mix, efficiency, and amount of pumping and estimates depth to water. This information is then returned to the CVPM where pumping estimates can be revised based on groundwater cost as a function of its depth.

Water Costs. Water costs per unit water are input data for the CVPM and are a cost of production used in estimating net returns. The CVPM alternatives analysis includes three water price tiers, and the CVPM can select the least-cost response to price tiers in terms of crop mix, water use, land fallow, and irrigation technology.

Water Acquisition and Land Retirement. Water acquisition and land retirement in each Alternative are included through adjustments to the hydrology models, and land use changes are included in the CVPM. The CVPM is used to estimate the cost of water acquisition and land retirement using shadow prices provided as CVPM results.

Water Conservation Costs. An analysis of water conservation costs was conducted independently of the CVPM.

Water Transfers. CVPIA provisions allow CVP contract and settlement water to be sold to any water user in California. A modified version of the CVPM, the Central Valley Production and Transfer Model (CVPTM), was developed. This version allows water transfers between water users subject to feasibility, transfer costs and fees, and conveyance losses. The CVPTM accepts municipal and industrial (M&I) water demand functions from a M&I Water Use and Costs Analysis and estimates the quantity and price of inter-regional water transfers among agricultural water users and from agricultural users to M&I. It is also used to estimate the costs of water acquisition for fish and wildlife when that program must compete for water in an open transfer market.

Results

Results of the PEIS analysis of agricultural impacts will be made public this spring and will be presented at the WAEA summer meetings. In general, results show that agricultural users most affected by the CVPIA are likely to respond with a combination of greater groundwater use, reduced crop acreage, and modest irrigation efficiency increases. Direct costs imposed on agriculture are, in order of size; increased cost of CVP water, increased cost to pump replacement groundwater, net revenue lost by idling lands, and increased cost of irrigation system adjustments. Some agricultural users benefit as willing sellers for water acquired for fish and wildlife. Also, output changes in some regions cause price changes in other regions which affect agriculture.

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