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A Mathematical Programming Model of the U.S. Agricultural Sector

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The Basic Model

This agricultural sector model was originally developed by Baumas, and previously used in Burton; Tyner, et al.; Chattin, et al.; Hamilton; and Adams, Hamilton, and McCarl. Related versions have been used by USDA (House) and by Hickenbotham. This model has progressed through a number of stages over time and multiple versions exist. The version used here is described below.

Conceptually, the model is a price endogenous mathematical programming sector model of the type described in McCarl and Spreen. It is designed to simulate the effects of changes in agricultural product demand, yields, resource usage, and resources available, on the characteristics of the agricultural sector including agricultural prices, quantities produced, consumers' and producers' welfare, exports, and imports. In doing this, the model depicts production, processing, domestic consumption, imports, exports and input procurement. The model works from a set of regionalized production budgets for the primary crops and livestock to a set of processing budgets for the processing of these primary commodities. For production purposes the U.S. is disaggregated into 64 geographical subregions. Each region possesses different endowments of land, labor and water as well as crop yields.

The model distinguishes between primary and secondary commodities with primary commodities being directly produced by the farms and secondary commodities being those involving processing. There are 30 primary commodities and 21 secondary commodities as listed in Table 1. Some primary commodities (e.g. milk and soybeans) are inputs to the processing activities yielding these secondary commodities and certain secondary products (feeds and by-products) are in turn inputs to agricultural production.

Three inputs are available on a regional level: land, farm labor, and water. Production of crops and livestock compete for these scarce resources in each state or region. Three types of land are specified. Type 1 is land suitable for crop production. Type 2 is land suitable for pasture or grazing and the third type is animal unit months (AUMs) of grazing land. The labor input includes both family labor and hired labor. The model requires specification of a maximum amount of family labor available, and a reservation wage for family labor. The hired labor supply is based on an inducement wage rate and an elasticity. The water re-

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source is disaggregated into surface and pumped groundwater sources. The surface water is available for a constant price, but the amount of pumped water is provided according to a supply schedule where increasing amounts of water are available for higher prices.

There are two levels of regional disaggregation. The fundamental unit of disaggregation is 64 state and substate areas. These smaller areas are grouped into 10 larger regions for the purposes of land supply, labor supply and water supply. A list of these regions, and state and substate areas are given in Table 2 and are shown in Figure 1.

A total of 1,683 production possibilities (budgets) are specified to represent agricultural production. Some field crop activities are also divided into irrigated and non-irrigated activities according to the irrigation facilities available in each state or area. For each production possibility, information on yields, and usages of national and regional inputs or other commodities is required.

The model is constrained so that for each area the crop mix falls within one of the mixes observed in the past 25 years. Production may be sold in both domestic and foreign markets, and imports of products are allowed.

This model is used in this study as a simulator as it simulates changes in production patterns in the face of substantial policy alterations to which the reactions cannot fully be ascertained based on observable data.

Incorporation of the Farm Program and to the Policy Model

There are two major farm price and income support programs that are dealt with in the model; the commodity price support loan, and the target price and deficiency payment program. Both programs can affect commodity market equilibriums as well as causing significant government stock accumulation and expenditures.

Price Support Loans:

The price support loan program is assumed to create a floor market price. Under this program, farmers are assumed to receive a loan at the support price for each unit of commodity placed under the loan. The farmer pays the cost of storage and is free to sell the commodity at any time, but must immediately pay off the loan plus interest costs. The loan is "nonrecoursive" which means if the farmer does not sell the commodity by the due date, the commodity becomes the property of CCC in full payment of the loan. Therefore, the loan rate becomes a "floor" on the market price because farmers who cannot find a higher market price will forfeit their grain to the government. All grain in the market is assumed to be eligible for the loan rate.

Target Price and Deficiency Payment:

The target price is assumed to provide farmers with a direct payment (deficiency payment) amounting to the difference between the target price and the market price whenever the market price falls below the target price. The payment is only paid to the farmers who participate in farm programs based on their normal level of production.

Participation in farm program is voluntary and therefore so is eligibility for deficiency payments are voluntary. However, the participating farmers must remove a portion of their land from production. In turn, certain uses are allowed on those lands set-aside to keep them in compliance. Modeling of the farm program therefore must consider the fraction of the farmers

participating, the acreages they set aside, and the cost of keeping set-aside acreages in compliance.

Solution of the Model

The model simulates a long-run, perfectly competitive equilibrium as reflected in 1986 economic and policy parameters. Thus, the solution reflects those conditions that maximizes the area under the demand curves less the area under the supply curves. That is, the solution maximizes the sum of ordinary consumers' and producers' surplus, or net social benefits. It is a normative model in the sense that it projects how each sector in the economy ought to act, given its resource and policy constraints and given the overall goal of maximizing net social benefits. The model is positive to the degree that the resource and policy constraints, and the consumer and producer goals of maximizing consumers' and producers' surplus's, respectively, reflect reality.

For the empirical examples to follow, first a base solution under 1986 conditions was obtained. Then, alternative solutions were obtained under alternative assumptions about the production coefficients in the cotton and milk activities, reflecting assumptions about improved production technologies.

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Table 1. Commodity Coverage of Sector Model

Primary Commodities	Secondary Commodities
1. Cotton	1. Soybean meal
2. Corn	2. Soybean oil
3. Soybeans	3. Fluid milk
4. Wheat	4. Feed grain
5. Sorghum	5. Dairy protein feed
6. Rice	6. High protein swine feed
7. Barley	7. Low protein swine feed
8. Oats	8. Low protein cattle feed
9. Other livestock (horses)	9. Fed beef
10. Cull dairy cows	10. Veal
11. Cull beef cows	11. Nonfed beef
12. Cull dairy calves	12. Pork
13. Milk	13. High protein cattle feed
14. Silage	14. Butter
15. Hay	15. American cheese
16. Hogs for slaughter	16. Other cheese
17. Feeder pigs	17. Ice cream
18. Live (beef feeder) calves	18. Nonfat dry milk
19. Beef feeder yearlings	19. Cottage cheese
20. Slaughtered calves	20. Skim milk
21. Slaughtered nonfed beef	21. Cream
22. Slaughtered fed beef	
23. Culled sows	
24. Poultry	
25. Slaughtered lambs	
26. Feeder lambs	
27. Culled ewes	
28. Wool	
29. Wool incentive payments	
30. Unshorn lamb payments	

Table 2. States and Regions in Sector Model

Northeast
Connecticut
Delaware
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
Pennsylvania
Rhode Island
Vermont

Lake States

Michigan
Minnesota
Wisconsin

Northern Plains

Kansas
Nebraska
North Dakota
South Dakota

Appalachian

Kentucky
North Carolina
Tennessee
Virginia
West Virginia

Cornbelt
North Illinois
South Illinois
North Indiana
South Indiana
North East Iowa
Central Iowa
South Iowa
West Iowa
Missouri
North East Ohio
North West Ohio
South Ohio

Southeast

Alabama
Florida
Georgia
South Carolina

Delta States

Arkansas
Louisiana
Mississippi

Southern Plains
Oklahoma
Texas Central Blacklands
Texas Coast Bend
Texas East
Texas Edwards Plateau
Texas High Plains
Texas Rolling Plains
Texas South
Texas Trans Pecos

Mountain

Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Pacific

North California
South California
Oregon
Washington

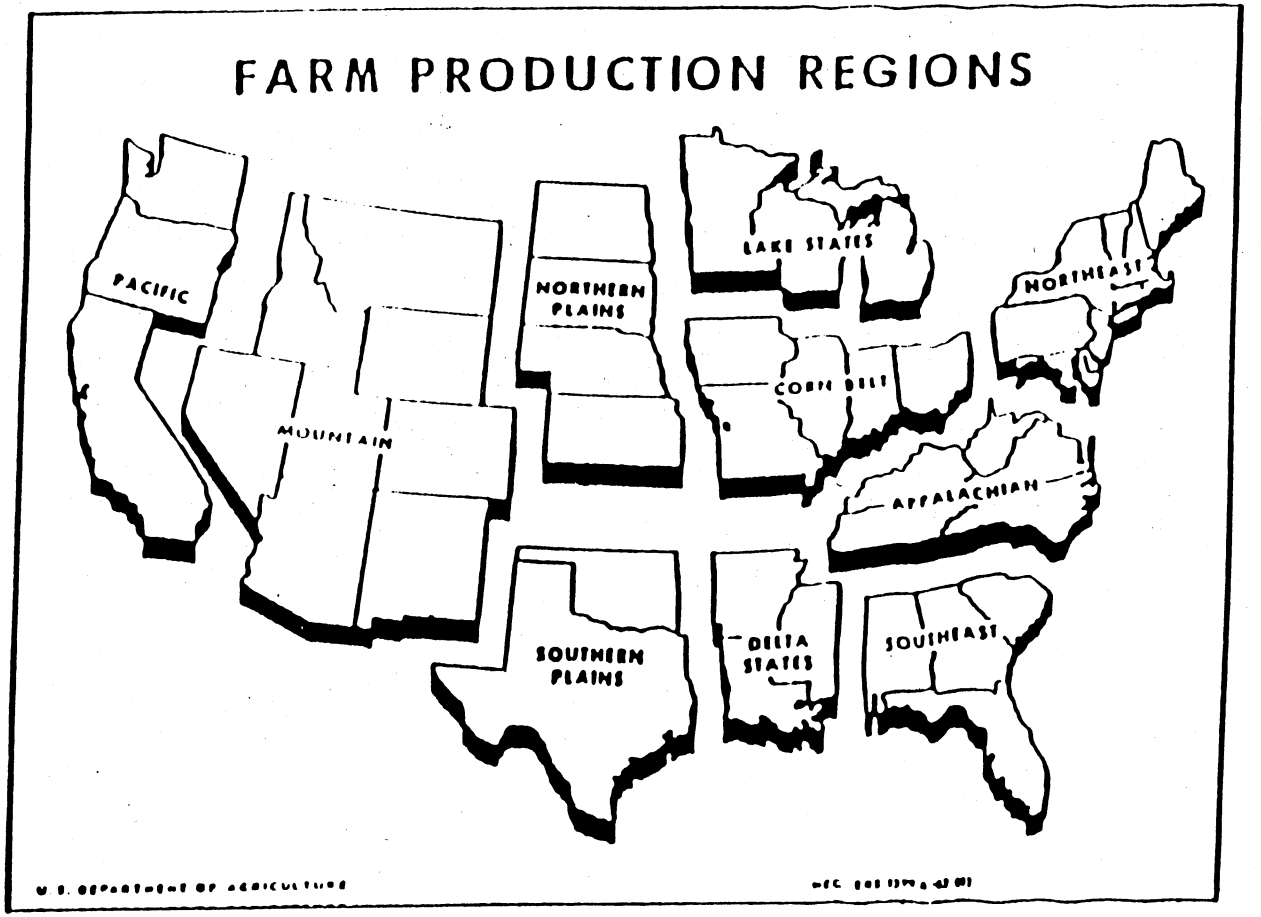

Figure 1. Farm production regions in the United States.

Source: USDA ERS.