POLYSIM: A National Agricultural Policy Simulator

By Daryll E. Ray and Theo F. Moriak

As an aid to providing expanded and more complete information to agricultural policymakers, an agricultural policy simulator (POLYSIM) was developed and used to analyze alternative agricultural policy proposals and economic conditions. This report describes what POLYSIM does and the types of problems for which it is useful.

Keywords: Agricultural policy analysis; Simulation.

INTRODUCTION

Policymakers at all levels need up-to-date, accurate information on available options and their likely impacts to help make decisions. As an aid to national agricultural policymakers, an agricultural policy simulator has been developed and used for analysis of alternative agricultural policy proposals and economic conditions.

The agricultural policy simulator (POLYSIM) was initially developed at Oklahoma State University in 1972. It has since been expanded and refined through cooperative agreements with the Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. This simulator can provide low-cost, quick, yet extensive analyses of policy proposals.

POLYSIM addresses policy questions as would persons who evaluate policy options. These people include the agriculture committees of the U.S. House of Representatives and the Senate, the executive branch, and others concerned with agricultural policy. Typically, they want to know how a policy change, such as adjustments in target price or loan levels, would affect prices and incomes of individual agricultural sectors as well as net farm income, Government costs, and consumer food prices.

Models exist that can estimate aggregate impact, on net farm income for instance, of pursuing policy stances such as free markets or general cropland retirement programs (*7*). There are also programing models that can estimate least-cost allocation of agricultural resources available to meet expected food needs under various policy environments (*1*, *4*). This first group of models referred to provides valuable intelligence about following a certain general course of action, but in a broad-stroke fashion. The second group gives information similar to POLYSIM, but the models assume perfect knowledge and optimum adjustment. Models of social systems dynamics have been developed for quick and inexpensive analysis of the behavioral response by farmers and consumers to policy changes affecting a given commodity (*5*). However, writers of agricultural policy legislation and administrators of enacted legislation often need quick analysis on how policies will affect livestock producers vis-a-vis crop producers, while allowing for imperfect knowledge and less than optimum response. In the past, no analytical device has been available that would provide such specific and detailed analysis without the prior assumptions of perfect knowledge and optimum adjustment.

DEVELOPMENT OF THE MODEL

The POLYSIM model was constructed differently from most simulation models to attain the desired policy analysis capability. The model makes full use of forecasted data as a reference baseline. Included are the five-year baseline projections of commodity supplies, prices, and use made by ERS. Commodity specialists develop these projections using formal and informal forecasting models tempered with their own experienced judgments. The projections contain explicit assumptions concerning the rates of change in population, per capita incomes, consumer preferences, export demand, technology (including crop yields and livestock gains), and other supply and demand shifters. These projections also assume a specific set of Government farm programs. In most policy analyses, the basic supply and demand shifters remain unchanged. It is the policy related shifts and indirect economic responses through the price mechanism that count in analyzing the impacts of alternative policy proposals. POLYSIM simulates the effects of policy specifications that differ from those assumed in the baseline while holding all other supply and demand shifters the same. The model thus focuses on the interaction of supply and demand responses that result from specified changes in policy variables.

Commodity supply and demand elasticities represent an important part of POLYSIM. The driving forces in the model are the initial and subsequent changes in commodity prices resulting from changes in policy conditions. The magnitude of impact is determined by direct and cross supply and demand elasticities. The elasticities used in the model were developed in stages. Initially, a comprehensive literature review was made to gather past estimates of the required elasticities. Secondly, many of the elasticities were reestimated, using more recent data. Finally, to make the model useful to ERS, commodity specialists reviewed the estimates, which had been categorized by commodity groups. The final revised esti-

mates are used as default values in the model, but users can change any of the elasticities if they have better or more recent information.[1]

OPERATION OF THE MODEL

Commodities included in the model are feed grains, wheat, soybeans, cotton, cattle and calves, hogs, sheep and lambs, chicken, turkeys, eggs, and milk. As indicated earlier, the model is designed to simulate around a set of baseline conditions. Base estimates must be available for all years analyzed in the simulated time frame. To date, most applications have been for a span of 3-5 years.

The user starts a simulation by changing one or more of the policy assumptions used in the base conditions; for example, by using a different series of loan rates. The simulation procedure traces through the effects on production, price, use, and farm income for each of the 11 commodity groups and on agriculture in the aggregate. Elasticities are used to calculate new values for the endogenous variables as deviations away from the base values. To simulate a change in an endogenous variable such as feed grain acreage, the percentage change between simulated and base estimates for the expected price variables is multiplied by direct and cross price elasticities. This operation results in a percentage change in feed grain acreage which is used to obtain a simulated value under the new policy assumptions.

As an example of the types of relationships possible in the model, the expected price, feed grain acreage, and cattle and calf production relationships were set up as follows:

Farmers' expectations of season average prices for feed grains, wheat, soybeans, and cotton were developed as:

Expected crop price (t) = Max [crop price (t-1), loan rate (t)]. These expected prices were used to estimate the movement away from baseline feed grains acreage. The season average feed grain price was linked to annual cattle and calf production as shown below:

Percentage change in	*Elasticity*	*Due to percentage change in*
Feed grain acreage (t)	.10	Expected feed grain price (t)
	-.03	Expected wheat price (t)
	-.06	Expected soybean price (t)
Cattle and calf production (t)	.11	Cattle and calf price (t-1)
	-.02	Hog price (t-1)
	-.01	Sheep and lamb price (t-1)
	-.05	Feed grain price (t-1)

[1] The authors can supply the list of default elasticities.

The percentage change in the left-hand variable is the sum of products of the elasticities and percentage changes in the right-hand variables (from their baseline values). The resulting percentage change in the left-hand variable is multiplied by its base value. Although not included in the example, each quantity equation has a geometrically distributed lag structure to allow multiperiod response to price.

The relationships and response variables used in the model appear in figure 1, which also indicates POLYSIM's complexity. Values for items in rectangles without asterisks are calculated by the model in a fashion similar to the above example while values for items in rectangles with asterisks are introduced exogenously. Many of the exogenous variables are policy instruments; others are included to make the model complete. POLYSIM is recursive in the sense that estimates for variables made during the year simulated may be used as causal variables for succeeding relationships in the same year and in later years.

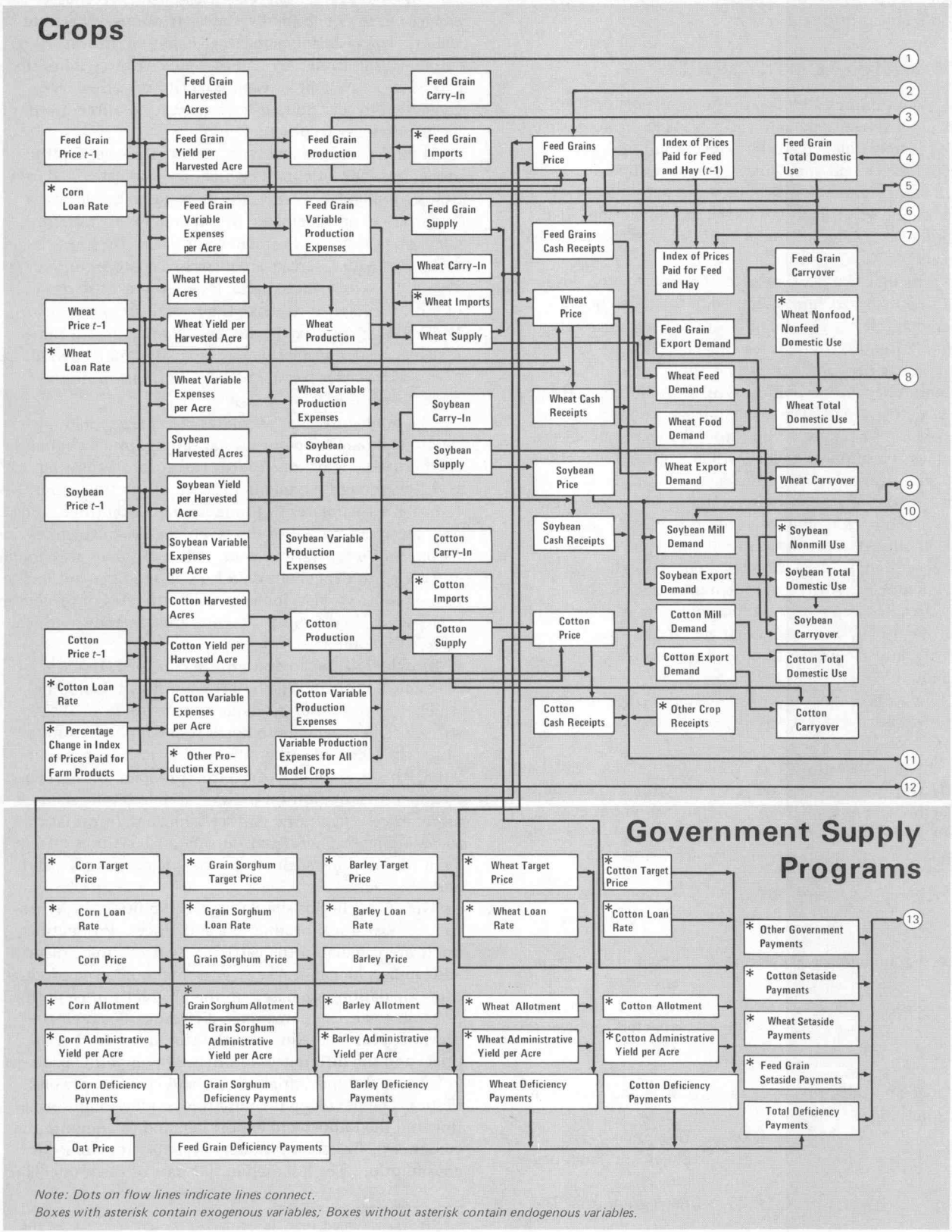
The model provides estimates of acreage, yield, production, variable expenses, total supply, price, commercial domestic demand, exports, carryover, cash receipts, and Government payments for each of the four crops. It also gives estimates of production, market price, and cash receipts for each of the seven livestock categories. Estimates for the various commodity variables are summed and added to exogenous data for commodities not included in the model—to develop aggregate estimates of production expenses, Government payments, gross income, and realized net income.[2]

The flow of the computer program for POLYSIM is diagramed in figure 2. The program uses baseline data which the computer reads and retrieves from disk storage. The program also needs user-supplied information, which includes the number of years to be simulated; the beginning year; farm program options; optional information on policy variable levels, such as target prices, loan rates, and set-aside; and information to be predetermined from outside analysis that differs from the baseline, such as exports, yields, imports, and harvested acres.

The model begins simulating for the first year by calculating livestock production and prices. Production levels are calculated for cattle and calves, hogs, sheep and lambs, chicken, turkeys, eggs, and milk. The production calculations are based on the product's price in the previous year, the percentage difference between the previous year's baseline and the simulated feed grain price, and the differences in prices of competing products times the appropriate direct and cross supply elasticities. The next step is to use this production information and the import and export demand to compute the amounts of livestock products available for domestic consumption. The last step in this part of the model is to

[2] It was assumed that the impact of policy changes on the exogenous commodities was not sufficient to significantly affect the aggregate variables at the national level.

SCHEMATIC DIAGRAM OF POLYSIM



Note: Dots on flow lines indicate lines connect.
Boxes with asterisk contain exogenous variables; Boxes without asterisk contain endogenous variables.

Figure 1

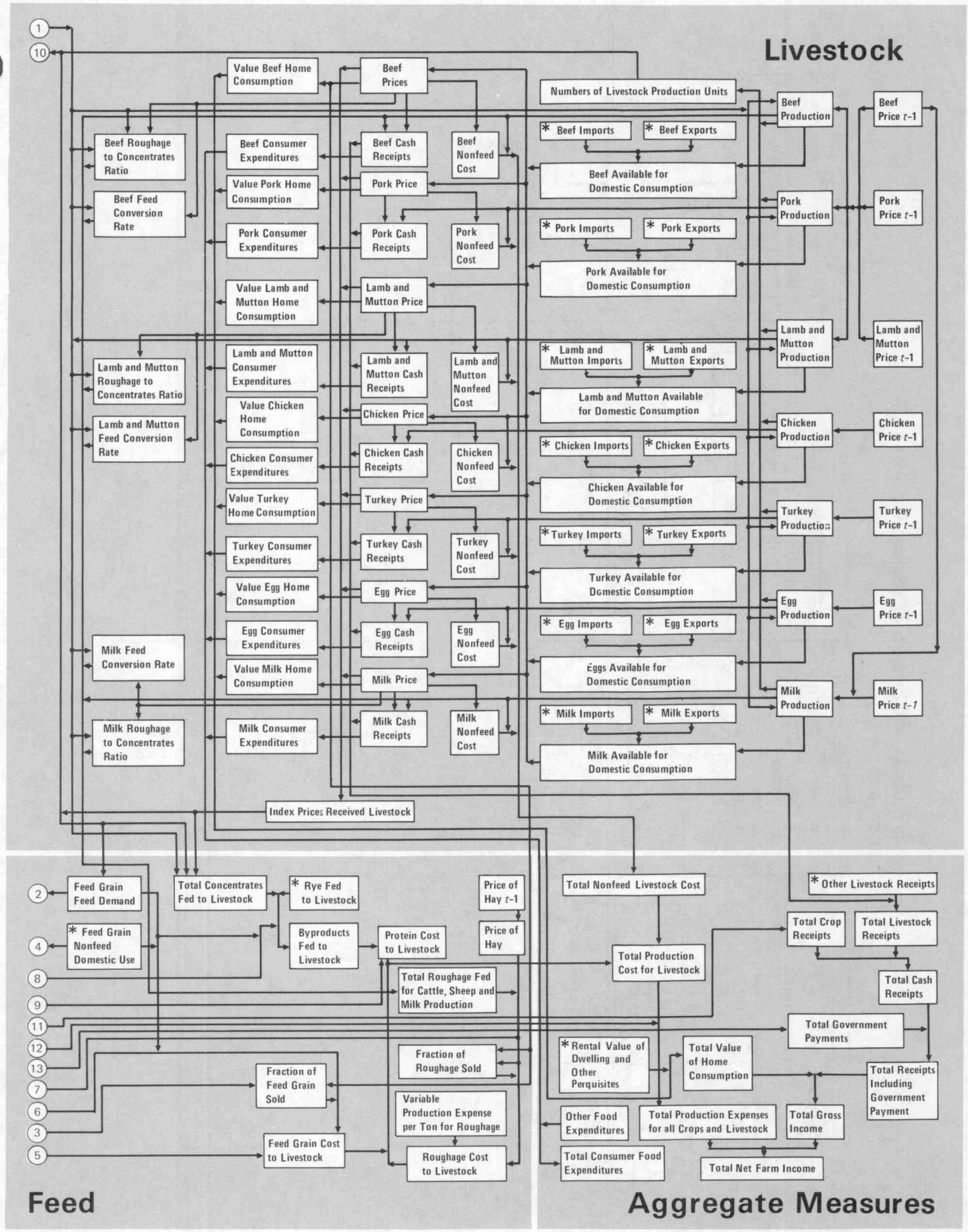
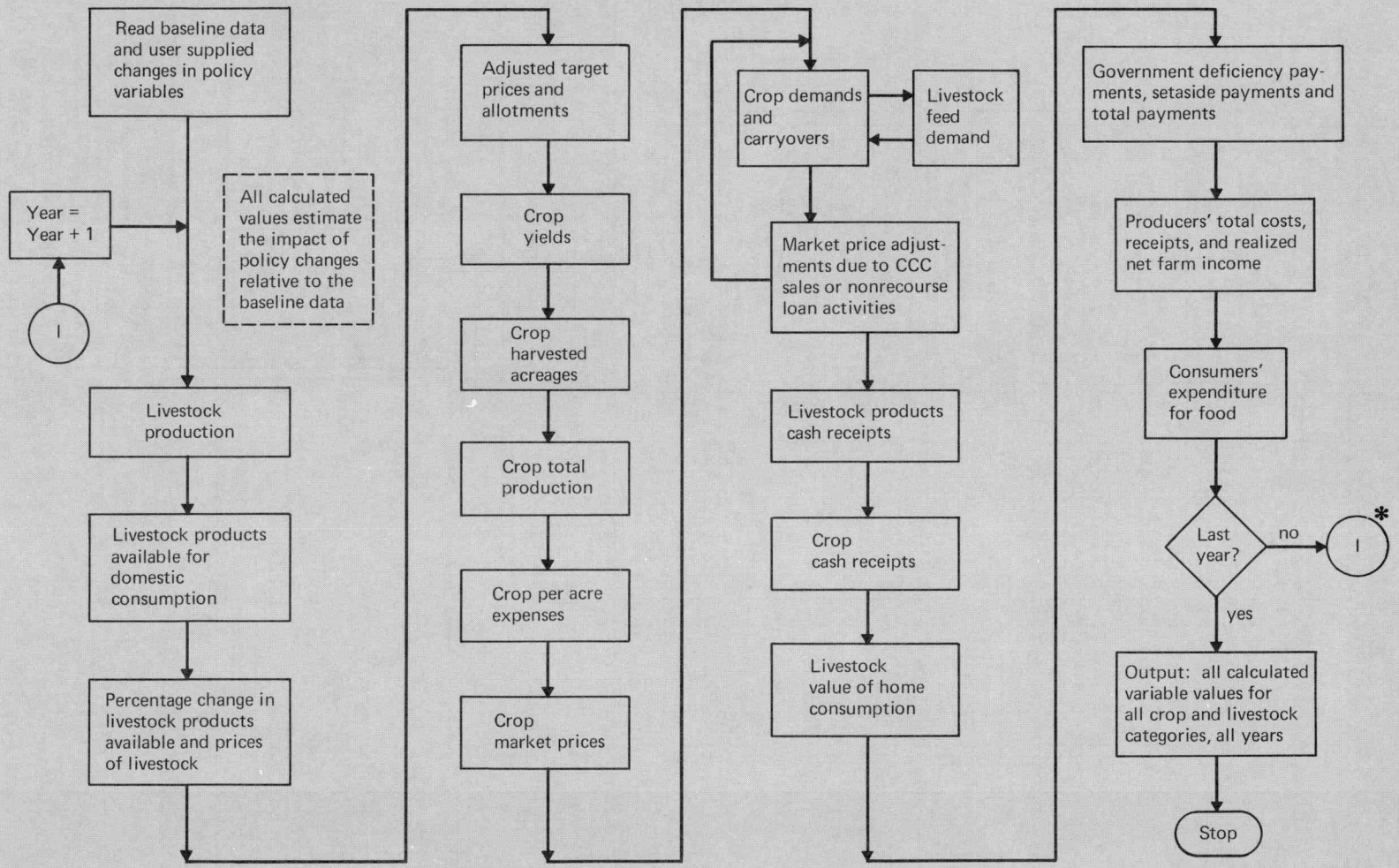


Figure 1—Continued

Flow Chart of Computer Program for POLYSIM



* Note: The computer is instructed to return to the beginning of its program to simulate another year.

Figure 2

calculate the percentage change in livestock product availability. By using farm direct and cross price flexibilities, the current year's price for each of the livestock products can be estimated.

As shown in figure 2, use of the seven-block series following the livestock calculations determines crop supplies and production costs for each crop. If the user desires, calculations will determine the adjusted target prices and allotted acreages for feed grains, wheat, and cotton.[3] If the loan rate exceeds the previous year's calculated market price, this rate is used as the expected price in calculating the supply response.

The harvested acreage for each crop is determined as a deviation from the baseline acreage, based on the percentage deviation in last year's market price for the crop from the baseline projections times the appropriate direct and cross elasticities. (See the earlier example in this section.) Yield and per acre production expenses are calculated with a similar equation. The total production for each crop is calculated directly as the product of the yield and harvested acreage. Total expenses equal per acre expenses times the harvested acreages.

The next two blocks in figure 2 represent current crop year price and demand. Crop prices are calculated using price flexibilities and the percentage change in crop supplies. Domestic and export demands depend on the percentage change in prices and the appropriate elasticities. The amount of protein and feed grains demanded for livestock feed is a function of livestock prices, feed prices, and livestock production. The carryover (stocks on hand at end of crop year) are computed as supplies minus demands.

The final six blocks within the model's simulation loop treat producers' costs, receipts, and income. Government payments depend on which farm program the user is simulating. Included are possible support payments based on the assumed target prices, market prices, and loan rates, and set-aside payments calculated as the product of acreage set aside and the rate of Government payment per acre. All such payments are summed to determine total Government payments for the farm program simulated. Aggregate or national estimates are made for total receipts; realized gross income; crop expenses; protein, feed, roughage, and nonfeed costs for livestock; total variable costs; total production costs; and realized net farm income.

OUTPUT, USE, AND LIMITATIONS OF POLYSIM

Figure 3 illustrates the type of information POLYSIM prints out in a summary table. The base values are shown, along with the values resulting from a specific policy or exogenous change in the agricultural outlook. The complete output of POLYSIM is 20 tables of annual estimates for each crop category, including yield; per acre costs; domestic and export demand; ending year stocks; and Government program parameters, such as loan rates, target prices, set-aside acreage, and Commodity Credit Corporation (CCC) acquisitions. Details of livestock production costs and quantities of feed fed are available as well as details on aggregate agricultural variables. A change in policy traces through to all these values; thus, the policymaker receives pertinent information about the effects of the policy change.

POLYSIM can be used to investigate the impact of changes in the following Government variables:

> Target prices and resulting deficiency payments, loan rates, alternative CCC buy-and-sell criteria, allotments, voluntary or mandatory set-aside acreages, per acre payment schedules for voluntary set-aside, program participation rates, and acreage or production quotas.

The effect of yield and export levels different from those in the baseline conditions can also be investigated. The policy, yield, and export levels may be changed from any one crop or combination of the four crops included in the model (feed grains, wheat, soybeans, and cotton). The user traces the effects of these changes through the interrelated crop sectors, the seven livestock sectors, and finally to national aggregates such as realized net farm income.

Operational at Oklahoma State University and in Washington, D.C. in ERS, POLYSIM has been used extensively at both locations. The focus in Washington has been on analysis of current economic issues while the emphasis at Oklahoma State has been on longer range research. Model extensions and modifications and computer input and output revisions continue at both installations.

During 1975, ERS used POLYSIM for several evaluations, including the impact of alternative levels of feed grain availability in the feed and livestock sectors and the effects of various levels of U.S. grain contributions to a world grain reserve. In early 1975, the House and Senate Agriculture Committees were hearing proposals for new agricultural legislation. POLYSIM was run frequently to aid evaluation of effects of the proposals on the crop sector and the general farm economy. A comprehensive analysis was made of the implications on production, prices, and incomes due to alternative energy cost increases and environmental restrictions (*6*). Recent applications at Oklahoma State have centered on evaluations of suggested rules governing stock procurement and release (*2*) and various combinations of target price and loan rate levels (*10*). These extensive simulations with POLYSIM were done at moderate cost since each computer run cost less than $2.

The validity of the model's results hinges on the accuracy of the baseline projections, or reference mode, used by POLYSIM, and the elasticity estimates. Both of these crucial information sets need critical

[3] Soybeans do not have target prices or allotted acres.

Sample Summary Table Printed by POLYSIM

1975 target & loan levels–H.R. 4296, targets adjusted by 1973 act for 1976-79

Item	1975		1976		1977		1978		1979	
	Base	Simulated	Base	Simulated	Base	Simulated	Base	Simulated	Base	Simulated
Harvested acreage										
Feed grains (Mil. acres)	102.60	102.60	103.70	103.70	104.60	104.60	104.90	104.90	106.00	106.11
Wheat (Do.)	67.50	67.50	65.50	65.50	63.70	63.70	61.90	61.90	61.90	61.88
Soybeans (Do.)	55.50	55.50	55.00	55.00	54.00	54.00	54.00	54.00	57.00	56.91
Cotton (Do.)	9.40	9.40	9.50	9.50	9.50	9.50	11.70	11.70	9.90	9.90
Production										
Feed grains (Mil. tons)	216.90	216.90	230.40	230.40	236.00	236.00	240.90	240.90	247.40	248.07
Wheat (Mil. bu.)	2,126.00	2,126.00	2,168.00	2,168.00	2,147.00	2,147.00	2,123.00	2,123.00	2,160.00	2,159.30
Soybeans (Do.)	1,500.00	1,500.00	1,500.00	1,500.00	1,485.00	1,485.00	1,510.00	1,510.00	1,610.00	1,607.39
Cotton (Mil. net bales)	9.80	9.80	9.90	9.90	9.90	9.90	12.00	12.00	10.40	10.40
Cattle (Mil. lbs. carcass)	25,300.00	25,300.00	27,000.00	27,000.00	27,000.00	27,000.00	27,800.00	27,800.00	27,700.00	27,685.03
Pork (Do.)	11,800.00	11,800.00	11,600.00	11,600.00	13,300.00	13,300.00	14,702.00	14,702.00	14,976.00	14,935.52
Sheep (Do.)	420.00	420.00	415.00	410.00	410.00	410.00	406.00	406.00	398.00	397.98
Chickens (Mil. lbs. ready-to-cook)	8,470.00	8,470.00	8,890.00	8,890.00	9,150.00	9,150.00	9,400.00	9,400.00	9,650.00	9,627.05
Turkeys (Do.)	1,840.00	1,840.00	1,950.00	1,950.00	2,020.00	2,020.00	2,080.00	2,080.00	2,150.00	2,145.35
Eggs (Mil. doz.)	5,220.00	5,220.00	5,440.00	5,440.00	5,600.00	5,600.00	5,720.00	5,720.00	5,830.00	5,824.33
Milk (Mil. lbs.)	115,500.00	115,500.00	117,000.00	117,000.00	118,000.00	118,000.00	119,000.00	119,000.00	120,000.00	119,974.00
Prices										
Corn (Dol./bu.)	2.25	2.25	2.00	2.00	1.90	1.90	1.85	1.87	1.90	1.90
Wheat (Do.)	3.15	3.15	2.75	2.75	2.50	2.50	2.50	2.50	2.50	2.50
Soybeans (Do.)	4.00	4.00	3.75	3.75	3.90	3.90	4.40	4.40	5.50	5.52
Cotton (Dol./lb.)	0.39	0.39	0.41	0.41	0.55	0.55	0.45	0.45	0.50	0.50
Cattle (Do.)	0.32	0.32	0.38	0.38	0.45	0.45	0.50	0.50	0.53	0.53
Pork (Do.)	0.41	0.41	0.46	0.46	0.32	0.32	0.32	0.32	0.33	0.33
Sheep (Do.)	0.38	0.38	0.40	0.40	0.42	0.42	0.44	0.44	0.46	0.46
Chickens (Do.)	0.26	0.26	0.23	0.23	0.20	0.20	0.20	0.20	0.21	0.21
Turkeys (Do.)	0.33	0.33	0.29	0.29	0.28	0.28	0.28	0.28	0.29	0.29
Eggs (Dol./doz.)	0.58	0.58	0.53	0.53	0.49	0.49	0.48	0.48	0.48	0.48
Milk (Dol./cwt.)	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
Cash receipts (Mil. dol.)	88,289.31	88,289.31	92,518.94	92,518.94	95,773.19	95,773.13	102,431.44	102,540.75	108,930.88	109,181.69
Crops (Do.)	43,539.00	43,538.98	41,775.06	41,775.05	42,014.98	42,014.94	43,156.42	43,265.79	46,539.72	46,595.89
Livestock (Do.)	44,750.36	44,750.36	50,743.92	50,743.92	53,758.23	53,758.23	59,275.02	59,275.02	62,391.18	62,585.81
Total Govt. payments (Mil. dol.)	200.00	523.40	200.00	5,929.19	257.13	7,328.64	200.00	6,395.49	200.00	6,737.70
Feed grains (Do.)	0.0	0.0	0.0	3,809.74	0.0	4,842.55	0.0	3,778.57	0.0	4,035.40
Wheat (Do.)	0.0	0.0	0.0	1,505.12	0.0	2,228.96	0.0	2,020.01	0.0	2,178.35
Cotton (Do.)	0.0	323.40	114.81	529.14	0.0	0.0	47.43	444.34	0.0	323.95
Gross farm income (Do.)	96,929.00	97,252.63	100,918.00	106,648.06	103,314.00	110,386.69	109,845.00	116,151.13	116,430.00	123,222.44
Production expenses (Do.)	77,000.00	76,999.94	83,900.00	83,899.94	87,200.00	87,199.94	93,030.00	93,109.31	98,730.00	98,774.19
Net farm income (Do.)	19,929.00	20,252.69	17,018.00	22,748.13	16,114.00	23,186.75	16,816.00	23,041.81	17,700.00	24,448.25

Figure 3

evaluation and updating continually to ensure that POLYSIM draws on the best information available at each point in time.

POLYSIM is not a tool for all problems. As a positivistic model, it cannot estimate optimum resource allocations for specific demand levels or productive capacity subject to resource constraints. Analyses of international stock reserve schemes are hindered because the world grain market is exogenous to the system. As with econometric projection models, users must anticipate and build in structural changes in supply and demand parameters. The model does not provide estimates of changes in the organizational makeup of agriculture, in land values, or in liability and asset variables found in national balance sheets of agriculture. However, output from the model, such as net farm income under various farm policy structures, could be inputed into other analytical models designed to make these estimates. Price variations during the year cannot be analyzed because the prices in POLYSIM are season averages for crops and calendar year averages for livestock. Also, the model cannot extend the baseline, but it may be useful in revising an existing baseline if the impacts are due only to variables in POLYSIM. Policies can be analyzed only over the period for which annual baseline projections are available.

However, as detailed earlier, POLYSIM does have considerable value for expanding the information agricultural policymakers need, either on its own or through linkage with other models.

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