THE USE OF EXTRANEOUS INFORMATION IN THE DEVELOPMENT OF A POLICY SIMULATION MODEL

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A number of highly aggregated policy simulation models have been developed for the U.S. agricultural sector. While these models are useful in providing broad-stroke sketches of the effects of alternative farm policies, they have been criticized for their lack of commodity detail. Individuals, organizations and congressmen from a cattle producing state, as an example, are more interested in the impact of a changed agricultural policy on cattle prices and incomes than its effect on the income of all farmers. The reason most often given for not disaggregating by commodity groups is the researcher's reluctance to quantify opportunities for substitution among commodities in production and consumption. However, there may be more agreement on the relative magnitudes of supply and demand elasticities for individual commodities than the price elasticities of supply and demand for all farm output. Hence, a disaggregated model may distort reality much less than a highly aggregated model and at the same time provide detail on indirect effects of proposed policies that is so often sought by policy makers.

Considerable information is available on direct and cross demand elasticities for agricultural commodities. The degree of methodological sophistication ranges from monocausal least squares estimates to elaborate models that provide large matrixes of direct and cross demand elasticities such as developed by Brandow [3] and more recently by California researchers [9]. While the repertoire of direct and especially cross supply elasticities for specific commodities is much smaller, estimates are available for a number of crops.

In addition to the price response parameters, nonprice related shifts in commodity supplies and demands must also be quantified in the development of a simulation model. The United States Department of Agriculture periodically projects commodity requirements and supplies for a number of years into the future. The considered judgment of commodity specialists is used in conjunction with sophisticated and naive models to analyze and project supply and demand levels for each commodity in an equilibrium framework. These projections are presumably superior to piecemeal or highly aggregated projections made by individual model builders. Estimates for years prior to the projection period can be made by interpolating between the last actual observation on the variable and the projected level for the future date which in this study is 1980.

The objective of this study is to develop a partially disaggregated policy simulation model based on supply and demand elasticities synthesized from previous studies and USDA supply and demand projections for 1980. Commodity groups included in the model are feed grains, wheat, soybeans, cotton, cattle and calves, hogs, sheep and lambs, chickens, turkeys, eggs and milk. The resulting model is used to estimate the impacts of alternative agricultural policy programs on an individual commodity production, price and income levels and on total farm incomes. The results of a free market policy are presented in this paper.

MODEL DEVELOPMENT

The projected commodity supply and distribution levels reflect the influence of two major sets of variables; changes in supply and demand shifters and changes in relative prices. Changes in population, national income, consumer preferences and technology are largely independent of happenings in the agricultural sector. Given the values of the shifters, it is the interaction of supply and demand

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responses to price that determine the economic well being of individual commodity sectors and national agriculture resulting from a change in agricultural policy. Hence, in the simulation model developed in this study, the non price-related supply and demand shifters (with the exception of government acreage diversions in some simulation runs) are fixed while direct and cross price elasticities of supply and demand allow adjustments in supplies and demands following a change in economic environment of farmers.

The procedure is to multiply the direct and cross price elasticities for a commodity series (say feed grain acreage) by the percentage change between calculated and base estimates for the relevant price variables (say previous year prices of feed grains, wheat, soybeans, and cotton). The results of these calculations are summed, added to one, and then multiplied times the base estimate for the series (feed grain acreage in time t). Since the long run response of supply and demand to a sustained price change often differs from the short run response, each relation allows for cumulative price response via an adjustment coefficient.

To illustrate the general procedure, the equation to estimate feed grain harvested acreage for the 1973 crop year is:

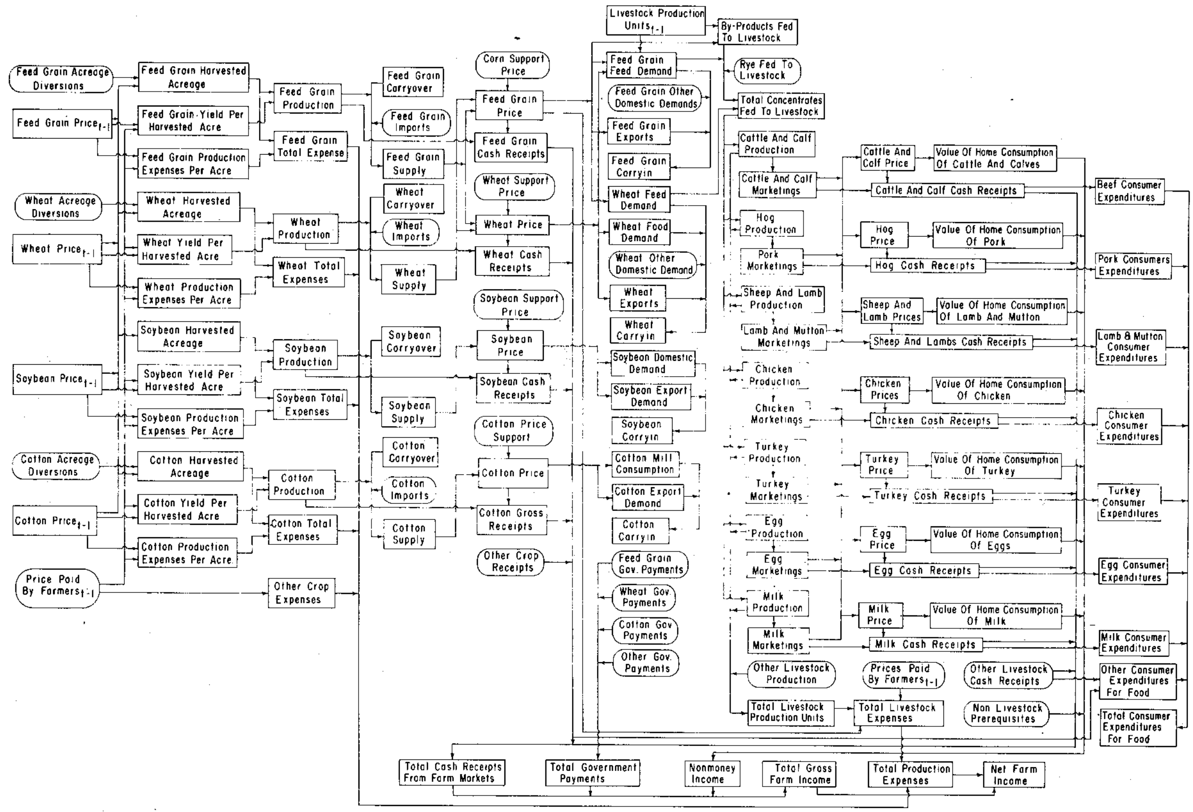
In short, the percentage price changes are confronted with the appropriate direct and cross elasticities to estimate the change in commodity supply and demand related variables.

Figure 1 indicates the implicit functional relationships of the model. With the exception of identities and variable levels determined by physical relationships and indexing procedures, the causal relations are tied together with a-priori elasticity estimates.

As is indicated by Figure 1, the model is recursive. Harvested acreages for feed grains, wheat, soybeans and cotton are related to previous year prices for the four crops and the index of prices paid by farmers. Deviations from base crop yield estimates depend on the percentage change in previous year price for the respective crop and the index of prices paid. The product of acreage and yield is used to estimate production for each crop. Production expenses per acre for each crop are adjusted for changes in the previous year price of the crop and changes in the index of prices paid. Total production expenses for each crop are defined as the product of that crop's acreage and expenses per acre. The crop supply identities include production, imports and carryover. Crop prices are dependent on the percentage change in calculated crop supplies and the

$$
\begin{aligned}
\text{Calculated Feed Grain Acreage}_{1973} = \Bigg\{ & \text{Base Feed Grain Acreage}_{1973} \times \Bigg[\Bigg[1.0 + \left(\text{Elasticity of Feed Grain Acreage wrt Feed Grain Price}\right) \times \left[\left[\text{Calculated Feed Grain Price}_{1972} - \text{Base Feed Grain Price}_{1972}\right] \right.\\
& \left. \div \text{Base Feed Grain Price}_{1972}\right]\Bigg) + \left(\text{Elasticity of Feed Grain Acreage wrt Wheat Price}\right) \times \left[\left[\text{Calculated Wheat Price}_{1972} - \text{Base Wheat Price}_{1972}\right] \div \text{Base Wheat Price}_{1972}\right]\Bigg) \\
& + \left(\text{Elasticity of Feed Grain Acreage wrt Soybean Price}\right) \times \left[\left[\text{Calculated Soybean Price}_{1972} - \text{Base Soybean Price}_{1972}\right] \div \text{Base Soybean Price}_{1972}\right]\Bigg) + \left(\text{Elasticity of Feed Grain Acreage wrt Cotton Price}\right) \\
& \times \left[\left[\text{Calculated Cotton Price}_{1972} - \text{Base Cotton Price}_{1972}\right] \div \text{Base Cotton Price}_{1972}\right]\Bigg) + \left(\text{Elasticity of Feed Grain Acreage wrt Prices Paid by Farmers}\right) \\
& \times \left[\text{Percent change in Prices Paid by Farmers} \times .01\right]\Bigg]\Bigg\} + \left(1.0 - \text{Adjustment Coefficient}\right) \times \left(\text{Calculated Feed Grain Acreage}_{1972} - \text{Base Feed Grain Acreage}_{1972}\right)
\end{aligned}
$$

Figure 1. A SCHEMATIC DIAGRAM OF THE SIMULATION MODEL.



base supply estimates. The domestic demand categories and export demands are dependent on the percentage change between current and base estimates for current year prices of the crop and related commodities. Ending year stocks are calculated as residuals. Crop receipts are calculated as price times production adjusted for proportions sold.

The production levels of the seven classes of livestock are based on the estimate of all concentrates fed to livestock. Livestock prices are determined by the production levels of the livestock categories. Production and price levels determine gross receipts for each livestock category. The number of livestock production units, calculated from production estimates, influences livestock production expenses. The sum of cash receipts for the four crops, the seven livestock categories and other crops and livestock products equals total cash receipts. Adding government payments and the value of home consumption (adjusted for changes in the prices of the individual livestock categories) to total cash receipts yields total gross farm income. Total production expenses are calculated as the sum of individual crop expenses, other crop expenses and livestock production expenses. Net farm income is the difference between total gross farm income and total production expenses.

SUMMARY OF BASE PROJECTIONS

As indicated earlier, the base data used in the model are derived, for the most part, from 1980 projections made by United States Department of Agriculture and specifically by the Outlook and Projections Branch, Economic and Statistical Analysis Division of the Economic Research Service. Some of the projections are published in the July 1970 issue of Agricultural Economics Research [7] but a newly revised and updated statistical appendix to the article, available from the Outlook and Projections Branch, provided the bulk of the projections. 1980 projections were made by the USDA for commodity production, crop acreage and yields, price indexes by crop and livestock categories, commodity supplies and utilizations, and the components of the feed concentrate balance sheet.

Among the assumptions used by the USDA in making their revised projections are: a) a 1980 U.S. population of 231 million, b) a gross national product of \$2.1 trillion, c) average per capita disposable income of \$6,245, and d) the continuation of domestic farm programs and import restrictions on dairy and beef. Since the USDA 1980 projections are obtainable elsewhere [7], little space is devoted to them here. The prices used in the study were developed from USDA projected price indexes for commodity groups so as to be consistent with the supply and demand quantities. Estimates of crop production expense per acre for the four crops, total livestock production expenses and expenses for other crops for 1930-1967 were developed in an earlier study by Ray [22]. A trend analysis of these expense series along with published USDA expense estimates was used to project the 1980 production expense series. Total production expenses in 1980 are estimated at $60.2 billion compared with $44.0 billion in 1971. Direct payments to farmers under the various governmental farm programs are assumed to be $4.0 billion. Of this total, feed grain producers are assumed to receive $1800 million, wheat producers $925 million and cotton producers $875 million. Variable data for 1972 to 1979 were generally derived by interpolating between the last published estimate (usually 1971 but some preliminary 1972 estimates were used) and the 1980 projection. Complete listings of the base data are available from the author.

PRICE RESPONSE PARAMETERS

Supply Elasticities

A change in relative crop prices influences a crop's production level through its effect on acreage and on yield. The acreage elasticity indicates the increase (decrease) in crop acreage resulting from a price rise (decline). The yield elasticity reflects change in the application of fertilizer, pesticides and other nonland inputs to each crop acre. As prices rise, farmers purchase and use larger amounts of yield-increasing inputs and, conversely, reduce input usage as prices fall.

Table 1 summarizes the short run and long run acreage and yield elasticities used in the model. The direct acreage elasticities were selected as being representative of empirical analyses conducted by other researchers. Nerlove [17] estimated the short run price elasticity for corn acreage at .09 and the long run elasticity at .18. Colyer and Irwin [5] derived a short run elasticity of feed grain production with respect to corn price of .11. Estimates of short-run acreage price elasticity for wheat varies from zero obtained by Bowlen [2] for nine western Kansas counties to .93 derived by Nerlove [17]. Cochrane's [4] informal estimate of wheat supply price elasticity (including both the acreage and yield components) was between .1 and .2. Vandenborre [19], Houck and Subotnik [15] and Heady and Roa [11] obtained soybean supply price elasticity estimates of between .8 and .9. Houck and Mann [13] derived acreage price elasticity estimates of .16 for the first crop year following a sustained price increase and .29 for the second crop year. Estimates of the elasticity for cotton obtained by Blakley [1] range from .16 for selected years during 1934-1956 when allotments were in effect to .75 for

Table 1. DIRECT AND CROSS ACREAGE AND YIELD SUPPLY ELASTICITIES, LONG RUN ELASTICITIES IN PARENTHESES

Elasticity of	Feed Grain Price t-1	Wheat Price t-1	Soybean Price t-1	Cotton Price t-1
Feed Grain Acreage	.10	-.05	-.03	-.01
	(.30)	(-.15)	(-.09)	(-.03)
Wheat Acreage	-.03	.10	-.02	-.01
	(-.06)	(.20)	(-.04)	(-.02)
Soybean Acreage	-.20	-.02	.30	-.03
	(1.00)	(-.10)	(1.50)	(-.15)
Cotton Acreage	-.02	-.01	-.02	.20
	(-.04)	(-.02)	(-.04)	(.40)
Feed Grain Yield	.15	--	--	--
	(.30)	--	--	--
Wheat Yield	--	.10	--	--
	--	(.20)	--	--
Soybean Yield	--	--	.15	--
	--	--	(.30)	--
Cotton Yield	--	--	--	.15
	--	--	--	(.30)

nonallotment years. Walsh [20] derived a short run acreage price elasticity of .2. Cromarty [6] obtained a supply price elasticity (based on production) of .361 while Cochrane's [4] judgment estimate was .2 to .3. The cross acreage elasticities and direct price elasticities for yield were adapted from a much larger simulation model developed by Ray [18]. The earlier econometric simulation model included submodels for feed grains, wheat, soybeans, cotton and tobacco. The cross supply elasticities were derived by changing a crop's price by 10 percent, noting the change in the acreage of competing crops and deriving the implied cross acreage elasticity for the crop. The direct price elasticities for yields were derived in a similar manner.

Demand Elasticities

The elasticity of feed grain demand was set at -.25 [3] in the short run and -.50 in the long run. Wheat flour price elasticity was estimated by Fox [8] at -.067, and a short run elasticity of -.10 (-.20 in long run) was used in the model. Gomme [10] suggests that wheat feed demand is relatively price responsive and is influenced to a considerable extent by feed grain prices. The short run elasticities used are -.50 for the direct price elasticity and .45 for the cross elasticity with respect to feed grain prices. Houck and Mann's [13] estimate of the domestic demand elasticity for soybeans of -.35 was used (.70 in the long run). Cromarty [6] estimated price elasticity of cotton mill consumption at -.30 and Lowenstein's [16] estimate was -.23. The short run estimate used is -.25 with -.50 for the long run. Price elasticities for export demands are assumed to be -2.00 in the long run and -.4 in the short run except for soybeans which has a short run elasticity of -.5. The price flexibilities used to determine individual livestock prices were taken directly from Brandow [3, p. 65].

Livestock Supplies

A matrix of parameters that measure the production response by class of livestock to changes in livestock prices and to changes in prices and/or production of livestock feeds would be highly desirable for use in a simulation model. Unfortunately, no internally consistent and integrated set of livestock supply parameters is available. However, Hassler [11], Shepherd et al [24] and Tweeten, Heady and Mayer [25] have developed procedures that incorporate feeding rates, phasing a commodity cycles, supply elasticities for individual livestock commodities and length of production periods to estimate the impact of changes in feed supplies and prices on production of the various livestock classes. Hassler used a set of equations to determine the equilibrium allocation of surplus feed production among livestock classes at a fixed price level for feed. Tweeten, Heady and Mayer implicitly allocated excess feed production resulting from an unrestricted production policy by determining the maximum rate of production expansion of various livestock categories consistent with livestock supply elasticities and expansion rates. Shepherd et al considered livestock supply elasticities feeding rates and length of feeding period in their allocation of estimated surplus feed grains resulting from a free market structure to the various classes of livestock.

A comparative analysis of these studies suggested that the difference between estimated and base concentrates fed to livestock would initially be allocated to livestock classes as follows: beef, 15 percent; pork, 55 percent; sheep and mutton, .5 percent; poultry meat, 19.5 percent; eggs, 5 percent; dairy, 5 percent; and other livestock, 0 percent. Hog, broiler and turkey production are assumed to exhibit the greatest initial response to changed feed supplies and prices. The production periods for hogs and poultry are short and grains make up a large proportion of their total rations. In the short run cattle expansion (contraction) is moderate, but adjustments in breeding stocks, feeding facilities, etc., allow marked changes in cattle production with the passage of time. In keeping with the implications of the Tweeten, Heady and Mayer analysis, the proportion of excess (deficit) concentrates allocated to cattle production is gradually adjusted so that after about seven years 40 percent of the surplus (deficit) feed is allocated to beef while 30 percent is allocated to pork.

Feed conversion rates for the various classes of livestock were adjusted slightly downward from their 1967-79 averages. Assumed levels of total concentrates fed per 100 pounds of liveweight production for the livestock classes are as follows: all beef, 245 pounds; pork, 480 pounds; sheep, 150 pounds; chickens, 300 pounds; turkeys, 475 pounds; milk, 844 pounds; and eggs, 600 pounds per 100 dozen. The base feeding rates were allowed to respond to changes in feed grain prices with an elasticity of -.1.

Production Expenses and Incomes

Each crop expense is calculated as the product of acreage and that crop's production expense per acre. Expenses per acre for each crop are adjusted for changes in the crop's price with the same short run elasticities as are used for yield. In the long run these elasticities are tripled to reflect longer term adjustments including changes in the use of polyperiod inputs such as machinery.

Table 2. **PRODUCTION, PRICES, UTILIZATION AND MARKET RECEIPTS BY COMMODITY CLASS AND NET FARM INCOME, BASE 1980 PROJECTIONS AND 1980 ESTIMATES UNDER AN UNRESTRICTED PRODUCTION POLICY.**

Item	Unit	1980 Base Projections	1980 Estimates With Programs Eliminated 1973
Production			
Feed Grains	Mil. tons	240.3	262.9
Wheat	Mil. bu.	1547.0	1863.6
Soybeans	do.	1650.0	1812.5
Cotton	Mil. R. bales	11.9	13.6
Cattle and Calves	Mil. live lbs.	51812.0	54449.8
Pork	do.	25120.0	26067.8
Sheep and Mutton	do.	714.0	775.6
Chickens	do.	15981.0	16725.4
Turkeys	do.	2896.0	3078.4
Eggs	Mil. doz.	6422.0	6614.7
Milk	Mil. lbs.	116100.0	116250.3
Prices			
Feed Grains	$/tons	40.00	31.21
Wheat	$/bu.	1.30	.95
Soybeans	$/bu.	3.00	2.70
Cotton	$/lb.	.25	.21
Cattle and Calves	$/cwt.	31.50	28.24
Hogs	do.	23.50	20.55
Sheep and Lambs	do.	27.45	24.82
Chickens	do.	14.00	12.28
Turkeys	do.	21.00	18.36
Eggs	$/doz.	.33	.29
Milk	$/cwt.	7.50	7.41
Total Concentrates Fed	Mil. tons	230.0	241.2
Feed Grains	do.	186.0	197.0
Wheat	do.	4.0	4.3
Other	do.	40.0	39.9
Other Domestic Utilization			
Feed Grains	Mil. tons	19.3	19.3
Wheat (including food)	Mil. bu.	674.7	701.5
Soybeans	Mil. bu.	1000.0	1059.7
Cotton	Mil. bales	8.5	9.6
Exports			
Feed Grains	Mil. tons	35.0	47.5
Wheat	Mil. bu.	740.0	1038.4
Soybeans	Mil. bu.	650.0	744.2
Cotton	Mil. bales	3.5	4.5
Total Crop Marketing	Mil. dol.	28958.2	27780.5
Feed Grains	do.	5478.8	4677.3
Wheat	do.	1870.3	1646.0
Soybeans	do.	4851.0	4788.0
Cotton	do.	1500.9	1412.0
Total Livestock Marketings	Mil. dol.	41002.4	38716.4
Cattle and Calves	do.	20853.8	19646.9
Hogs	do.	5887.3	5343.7
Sheep and Lambs	do.	249.8	245.4
Chickens	do.	2502.8	2297.4
Turkeys	do.	605.3	562.4
Eggs	do.	2083.1	1896.1
Milk	do.	8520.3	8424.5
Total Government Payments	Mil. dol.	4000.0	400.0
Feed Grains	do.	1800.0	0.0
Wheat	do.	925.0	0.0
Cotton	do.	875.0	0.0
Other	do.	400.0	400.0
Total Farm Receipts	Mil. dol.	73960.6	66896.0
Farm Prerequisites	do.	4398.0	4364.0
Total Gross Farm Income	do.	78358.6	71260.9
Production Expenses	do.	60598.9	62520.9
Net Income	do.	17759.7	8740.1

APPLICATION OF THE MODEL

Reported here are the production, price, and income implications of eliminating acreage diversion and price and income support programs for feed groups, wheat, soybeans and cotton. Other programs including those for tobacco, wool, peanuts and rice are assumed to continue.

The initial response to elimination of crop acreage controls would be an increase in acreages planted to crops. For the purpose of this study, it is assumed that the removal of acreage restrictions for feed grains, wheat and cotton would add a "normal-yield equivalent" of 20 million harvested acres of feed grains, 12 million acres of wheat and 3 million acres of cotton in the first year. Table 2 summarizes the economic impact of this "unrestricted production policy" on specific commodity categories and aggregate farm incomes. To save space only simulation results for 1980 and the base 1980 variable levels are tabulated. The 1980 simulation estimates reflect agriculture's economic position after farmers have had seven years to adjust to the unrestricted production policy. By 1980, farm prices recover substantially from the extremely low levels of the first year of unrestricted production ($21 per ton for feed grains, 14 cents per pound for cotton). Model results indicate that farmers would not scale down production levels sufficiently by 1980 to balance supplies and demands at the base 1980 prices. The larger production levels depress cash receipts, due to inelastic demands, and increased production expenses. These results coupled with the elimination of direct payments under the feed grain, wheat and cotton programs, yield a reduction of net farm income of over one-half ($8.7 billion compared to $17.8 billion).

The free market estimates from this study are consistent with the findings of other research studies. For example, the aggregate simulation model developed by Quance and Tweeten [21] estimated a 1980 net income of $9.2 billion with free markets. With a continuation of present programs they estimate a 1980 net farm income of $14.7 billion. Free market net income estimates for other time horizons have been about 40-50 percent of income levels with historical programs in effect [13, 23, 18, 26].

SUMMARY AND CONCLUSIONS

This paper is largely methodological in nature. Its purpose is to suggest one method of developing a simple commodity-disaggregated policy model that incorporates the professions' best estimates of commodity supply and demand requirements for a future point in time. Unlike many highly aggregated models, the impacts of a policy change on production, price and income levels of major farm commodities are estimated by the model as well as the policy's effect on national farm income. Furthermore, no optimization assumptions are superimposed on the system. Commodity production, price and income levels are positivistically determined via the dynamic and interdependent supply and demand structures. The validity of the model rests solely on the validity of the parameter estimates fed into the model and the accuracy of the base projections. Even though some of the parameter estimates used in the model are based on meager information, the synthetic development of the model allows the researcher to draw on the expertise of researchers who have spent months or years analyzing a supply or demand structure for a commodity or commodity group.

The model is not complete since only four crops are included endogenously in the model. A larger model with additional crop categories would be desirable. Furthermore, the influence of stochastic influences such as weather fluctuations and disease problems are not incorporated into the model.

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