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AGSEM:
An Agriculture Sector Equilibrium Model
*Description
*Example Analyses
*Data

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I. INTRODUCTION

Since early 1973, ESCS has been faced with an increasing number of questions involving the impact of the energy crisis on agriculture, the prospects for food prices in the short and intermediate run, the possible impact of new technologies, the ability of U.S. agriculture to meet changing domestic and world needs, and recently questions concerning 100 percent parity demands by farmers. While these issues may appear separate, they are all, in a sense, components of the same basic problem--how key physical, economic and policy changes affect the ability of the U.S. agriculture to meet anticipated demands over the next decade.

Numerous components of this general question are subjects of separate research projects underway in ESCS. However, policymakers in agriculture are still looking for analyses that will aid them in appraising future levels of production that may be expected at alternative price levels, the impact of input scarcities, input productivity under alternative technologies and the level of food and farm prices anticipated from the future balance of supply and demand. The Agricultural Sector Equilibrium Model (AGSEM) is designed to provide an overview of such relationships.

II. OBJECTIVE OF THE STUDY

In 1974, Ericksen (5) observed that the analyses of production capacity involved four basic factors or types of information: (1) the supply relationship in both a positive and a normative economic sense, (2) demand of both the domestic and export sectors, (3) the resource base available to U.S. agriculture and (4) the nature of technological advance in agriculture (the productivity of

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Numerous components of this general question are subjects of separate research projects underway in ERS. However, policymakers in agriculture are still lacking an integrated [illegible] to aid them in appraising future levels of production that may be achieved at alternative price levels, the impact of input scarcities, input productivity under alternative technologies and the level of food and farm prices anticipated from any future balance of supply and demand. The Agricultural Sector Capacity/Production Model (ASCAP) is designed to provide an overview of such relationships.

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In 1974, Ericksen (5) observed that the analyses of production capacity involved four basic factors or types of information: (1) the supply relationship in both a positive and a normative economic sense, (2) demand for both the domestic and export markets, (3) the resource base available to U.S. agriculture and (4) the effects of technological advance in agriculture (the productivity of resources in agriculture). AGSEM provides the capability to evaluate the relationships of these four factors within the U.S. agriculture using a highly aggregate mathematical programming model.

The model is designed to trace the general impacts of exogenous factors on the performance of the U.S. food and fiber sector. It is not designed to make statistically precise estimates, but rather to identify the set of impacts, indicate their directions, and provide a preliminary estimate of their magnitude. The basic procedure is to identify the nature of the exogenous factor from sources outside the project and include it in the model in the form of revised coefficients, new production processes or restrictions. The methodology thus provides capability for (1) determining the relative importance and possible impacts of a multitude of potential issues, (2) assisting in the choice of particular issues that warrant more in-depth analyses and (3) integrating the results of other research projects that are in the specific areas of supply, demand, resources and technology.

III. THE MODEL

The Agriculture Sector Equilibrium Model (AGSEM) utilizes quadratic programming to estimate the competitive equilibrium situation that results in the U.S. agriculture given domestic and export food and fiber requirements, technologies, resource availabilities and methods of production and marketing. The general domain of the model is the U.S. food and fiber industry including farm input supplies, the farm production sector, the marketing sector, and the export sector.

The theoretical ramifications of using a quadratic programming model to estimate a competitive equilibrium are well summarized by Heady and Srivastava (7, Ch. 11). In their terminology, AGSEM could be called a "partial competitive resources in Agriculture). ASECM provides the capability to evaluate the relationship of these four factors within the U.S. agriculture using a highly aggregated mathematical programming model.

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The theoretical ramifications of using a quadratic programming model to estimate a competitive equilibrium are well summarized by Heady and Srivastava (7, Ch. 11). In their terminology, ASECM could be called a "partial competitive equilibrium" in which an equilibrium is reached in only one subsector of an economy. Two characteristics distinguish this partial competitive equilibrium: (1) some prices and costs are fixed and (2) no alternative uses for resources are defined other than as inputs to the production processes of the subsector. Therefore AGSEM represents a partial competitive equilibrium to the agricultural sector, given the assumed external prices and resource uses. It implicitly involves all the assumptions made concerning equilibrium under perfect competition, suffers from the same weaknesses, and shares in the usefulness of this body of economic theory.

A. Algebraic Formulation of the Model

In matrix notation, the general quadratic programming problem is to:

(1) Maximize $F(\lambda) = d'\lambda + \frac{1}{2}\lambda' D\lambda$

(2) Subject to $A\lambda \leq b$

(3) and $\lambda \geq 0$

The objective function is quadratic in prices and is the sum of a linear form and a negative semi-definite quadratic form. This can be thought of as a regular linear programming problem, but instead of selling all output at a fixed price, price decreases as the quantity sold increases. The technology matrix and the resource vector in equation (2) have the same interpretation as in a linear programming sector model.

In equation (1), the quadratic form is multiplied by ½ to represent a perfectly competitive equilibrium rather than a monopoly-monopsony equilibrium. Since the algorithm used in computing a solution to this problem basically equates marginal costs and marginal returns, a monopoly-monopsony solution is computed unless the demand and supply functions are flattened by the factor of ½.

It should be noted that quadratic programming is not an optimizing proced-

ure in the usual sense--it is merely a mathematical technique to solve for the equilibrium prices and quantities that equate supply and demand in the multi-commodity case. The specific quantity maximized is analogous to net social benefits (the area to the left and between the supply and demand curves)--this is done as a convenience to solve for the intersection of the supply and demand curves. It will be shown, in discussing the estimation of coefficients for this model, that choice of proper cost coefficients can make this model more positive than normative.

To describe the quadratic programming model, let us partition the vector processes into five components:

v = purchases of farm inputs

w = quantities of products delivered to final demand

x = farm production levels

y = domestic marketing activities, and

z = exporting activities.

In a similar manner, the technology matrix A may be partitioned as follows:

$$\lambda' = \begin{bmatrix} v & w & x & y & z \end{bmatrix} = \begin{bmatrix} \text{processes} \end{bmatrix}$$

$$A = \begin{bmatrix} -A_v & 0 & A_x & 0 & 0 \\ 0 & 0 & -A_x & A_y & A_z \\ 0 & A_w & 0 & -A_y & -A_z \end{bmatrix} = \begin{bmatrix} \text{inputs} \\ \text{intermediate products} \\ \text{final products} \end{bmatrix}$$

In the partitioned A matrix, the columns are the same as the partitions in the λ vector and the rows are partitioned into those dealing with inputs, intermediate products and final products.

The quadratic programming problem is then to:

(4) Maximize $F(v,w,x,y,z) = -f'v - \frac{1}{2}v'Fv + d'w + \frac{1}{2}w'Dw - c'x - m'y - e'z$

(5) Subject to: $-A_v v + A_x x \leq b_i$

(6) $-A_x x + A_y y + A_z z \leq b_{sd}$

(7) $A_w w - A_y y - A_z z \leq 0$

(8) and $v,w,x,y,z \geq 0$

where the additional variables are

$(-f-v'F)$ = the supply functions for farm inputs composed of the intercept and the negative semi-definite quadratic matrix F--at the optimum inputs quantities $\bar{v}$, the per unit cost of inputs equals $(-f-\bar{v}'F)$

$(d+w'D)$ = the demand functions for final products--at the optimum quantities $\bar{w}$, the price of final products is $(d+\bar{w}'D)$

c = the per unit cost of farm production processes

m = the marketing bill costs for the marketing processes

e = the costs of export activities, defined as the difference between export unit values and the equilibrium domestic prices

b_i = the inputs available to the farm production subsector

b_{sd} = the net decreases in stocks of intermediate products

Equation (5) represents the restrictions on input use and restricts input use to the sum of inputs purchased and those on hand. Equation (6) controls the flow of immediate products and restricts those used by the marketing and export sectors to the quantity produced on farms plus the net decreases in stocks. Equation (7) represents flows of final products and restricts those meeting final demands to the quantity provided by the marketing and export sectors.

B. Model Structure

The quadratic programming activities represented by v and w in equations (4) to (8) were transformed into a linear programming tableau corresponding to the piece-wise linear approximation of the respective social benefit (cost) functions, a procedure described by Duloy and Norton (2).[1/] The specific formulation in

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1/ A prototype version of the model was solved with a quadratic programming algorithm written in FORTRAN by Lond and Powell (9) and reported by Miller and Millar (12).

AGSEM features additive separable segments, each with a specific bound for demand and supply functions. The transformation involved definition of n steps for each demand function w, such that:

$$(9) \quad \sum_{i=1}^{n} w_i p_i \sim d'w + \tfrac{1}{2}w'Dw$$

where the optimum quantity $\bar{w}$ is represented by the number of steps $\bar{n}$ in the optimum solution such that

$$(10) \quad \sum_{i=1}^{\bar{n}} w_i = \bar{w}.$$

Supply functions were similarly transformed.

The equivalence of the additive segment formulation and more conventional convexity restraint formulation has also been demonstrated by Duloy and Norton (3). The advantages of the additive segment formulation being: (1) computational efficiency via use of standard linear programming algorithms with bounding capabilities versus quadratic programming algorithms, (2) relaxing the linear restriction on demand and supply functions, and (3) expression of model coefficients in forms directly observable in demand and supply schedules.

In AGSEM, constant elasticity demand and supply functions were specified, which provide more reasonable estimates of prices and quantities over a wider range than linear functions. As a computational convenience, all product demand and input supply functions are represented without cross elasticities.

C. Aggregation Level of Model

The aggregation philosophy followed in constructing AGSEM was suggested by Hilarius Fuchs and Jerry Sharples. The basic idea is that if only one commodity is to be specified, that commodity should represent all agricultural products. If two commodities are specified, for example, crop products and livestock products, they still add to the same total as the one commodity formulation. This

philosophy is followed both in respect to disaggregation over commodities and in respect to disaggregation over subsectors, inputs and resources. Thus, regardless of the model detail and the particular rows and columns specified, the results always add up to the same totals. As an example, total agricultural exports is estimated regardless of the number of demand categories specified.

The current model specifies three farm input categories, twelve farm production activities divided among four producing regions, three marketing activities, four domestic demand categories and four export demand categories. Figure 1 shows the commodity categories of the model and illustrates the intermediate and final product flows between farm production, marketing and demand sectors. The data in figure 1 refer to 1976, the assumed baseline or benchmark period for the model.

Appendix A reveals more model detail, including data base organization and management and activities included in the model as partitioned under the algebraic formulation. As shown in Appendix A, AGSEM is a fully developed mathematical programming system composed of a data base, matrix generator, optimization model and final report writer.

D. Estimation of the Coefficients

The nature of the quadratic programming problem and its relationship to linear programming was used to formulate AGSEM so that its benchmark solution exactly duplicates 1976 historical data. Takayama and Judge (15, p. 20) state the reducibility theorem of quadratic programming: If a solution to a quadratic programming problem is known, then a linear programming problem can be formed from this information that will provide an identical solution. It follows that the gross return from each activity in a quadratic programming solution equals the summation of its input requirements times their shadow prices plus (or minus) the objective function value, in the same manner as in a linear programming

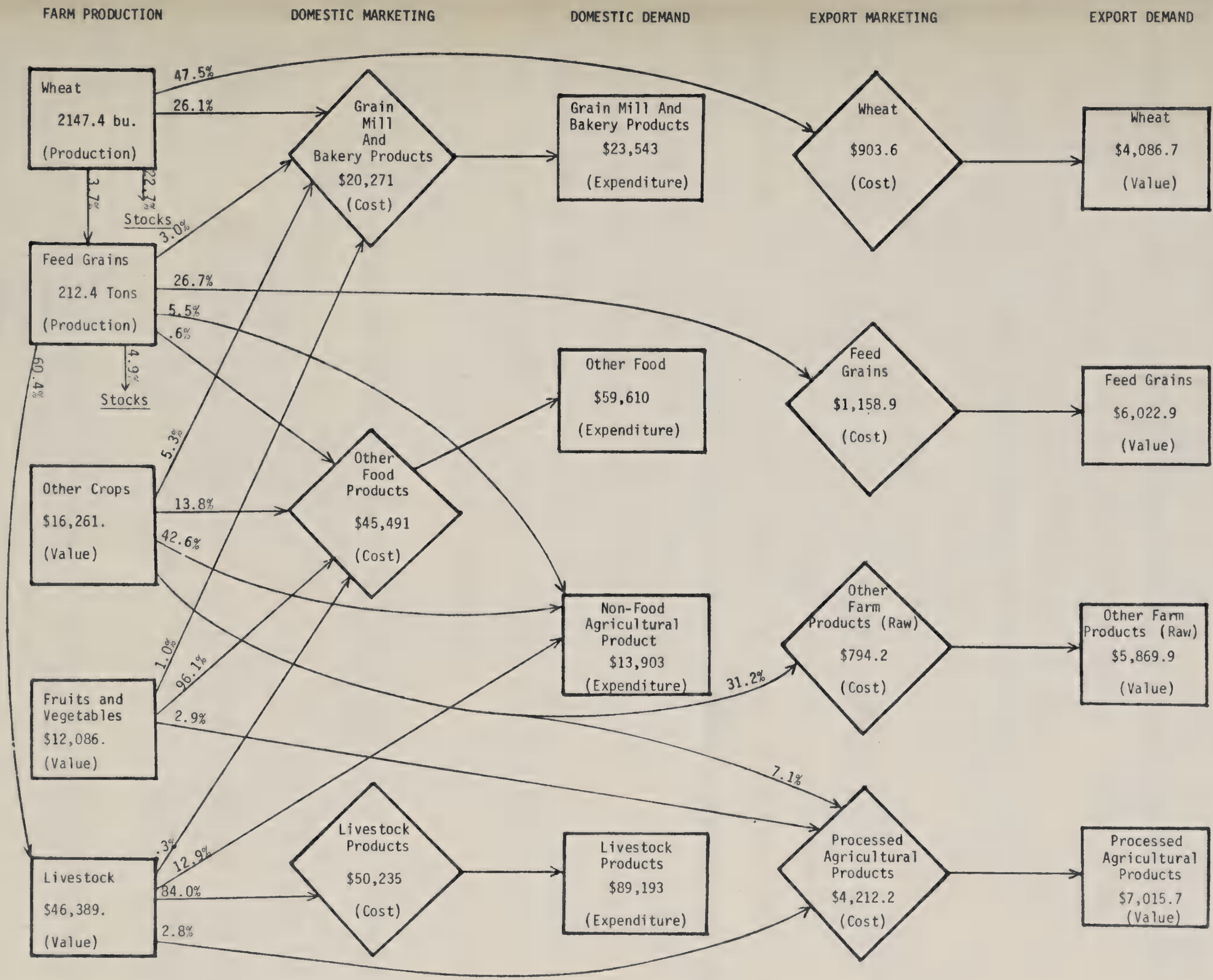

Figure 1. Commodity Categories and Product Flows Included in AGSEM, 1976, million units.

solution. For AGSEM, shadow prices were known for labor and for other farm inputs and were estimated for land as one-third of the gross return. The objective function coefficients for the production activities were then defined as the residual cost.[2/] Estimating these objective function coefficients as the residual cost assures that all of the agricultural production activities will be in equilibrium at their exact historical (1976) level since costs thus defined are exactly equal to gross returns at equilibrium prices.

Wherever possible, data came from recently published ERS Situation Reports and similar publications. All coefficients in the technology matrix represent the ratios implied by the 1976 data. For example, the labor requirement per acre of wheat was estimated as the total labor used in farm work for wheat divided by the total acres of wheat harvested. The demand and supply functions were specified so that they passed through the point represented by the appropriate 1976 price-quantity combination. The slopes of domestic demand and supply functions were based on elasticity estimates available from secondary sources. Where appropriate, the data currently in the POLYSIM model were used (14). Food demand elasticities were estimated from data published by George and King (6) and Mann and St. George (10) averaged into the food demand categories of AGSEM.

Export demands required further investigation in light of recent debate between Johnson and Tweeten in the AJAE (8 and 17). The elasticity of foreign demand for U.S. agricultural products was judged by both Johnson and Tweeten as elusive but of great importance. The technique forwarded by Tweeten and refined by Johnson was used to develop elasticities for the four export demand categories

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2/ Traditionally, the objective function values for production activities have been based on enterprise cost budgets. The procedure used in AGSEM results in objective function values that represent the 1976 residual return to all unspecified fixed factors.

of this model. The well-known excess demand concept is the basis for this technique. The calculating device is:

$$(11) \quad e_{xi} = E_{di} \frac{Q_{di}}{O_{ei}} - E_{si} \frac{Q_{si}}{O_e}$$

where

e_{xi} = elasticity of excess demand for commodity i

E_{di} = the net price elasticity of commodity i in foreign country

E_{si} = the elasticity of supply of commodity i in foreign country

$\frac{Q_{si}}{O_{ei}}$ = relative weight of U.S. exports (O_{ei}) commodity i to world supply of commodity i (Q_{si})

$\frac{Q_{di}}{O_{ei}}$ = relative weight of U.S. farm export (O_{ei}) of commodity i to world demand of commodity i (Q_{di}).

Equation (11) was used to compute export demand elasticities at 1976 quantities and prices--however constant elasticity functions were used to assure minimal exports at high prices. U.S.D.A. situation reports and circulars contained the raw data to determine elasticity estimates.

E. Estimates of Welfare Concepts

Quadratic programming provides a means of making empirical estimates of the total social benefit, social cost and net social benefit welfare concepts. As discussed earlier the mathematical algorithm which was used in solving the quadratic programming model maximizes net social benefits. Takayama and Judge characterize the objective function as a "net quasi-welfare function" (15, p. 237, equation 12.2.1). Basically, total social benefit is the summation of all areas below the demand curves and to the left of the equilibrium quantities, which is the summation of areas j, k, l and m in Figure 2. Total social cost is represented by the areas below the supply curve and to the left of the equil-

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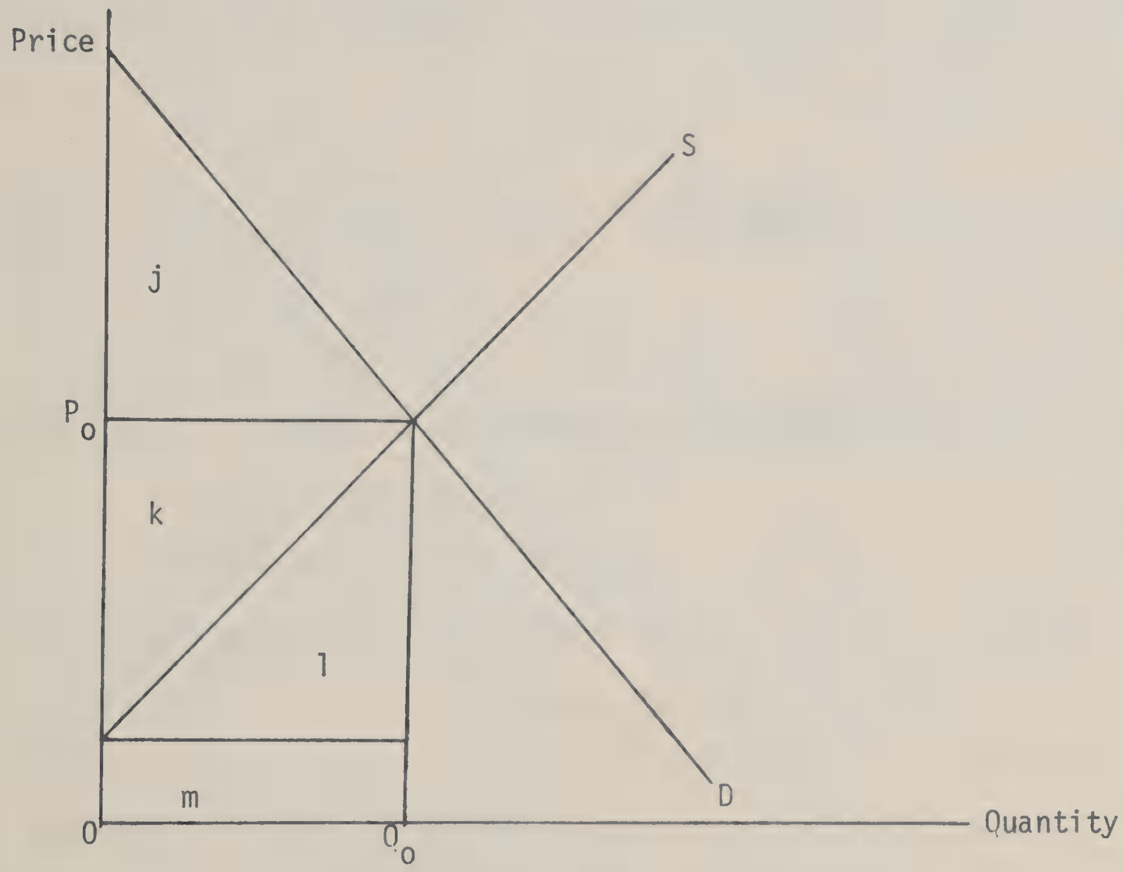

Figure 2. Hypothetical illustration of net social benefit concepts.

ibrium quantities. These social costs are made up of two categories of components: (1) the total cost (the product of the activity level times its cost) of activities that are not represented by upsloping supply curves, represented by area m, and (2) the area under the supply curve for inputs with inelastic supplies shown by area 1. Following Tweeten (16 and 18), net social benefit is then the difference between total social benefit and total social cost, or areas j and k. These net social benefits may be divided into consumer benefits, the area j above the equilibrium price, and producer benefits, the area k below the equilibrium price.

Controversy prevails concerning the use of these welfare concepts in public policy decision making; Mishan provides a detailed account of the problems (13) and more recently Mann has summarized the issues (11). For our purposes, several key assumptions must be remembered in interpreting the net social benefit concepts which in turn tend to limit the usefulness of the measures. Four major assumptions are (1) the marginal utility of money is constant, (2) there is no income effect represented in the demand curve, (3) that substitutes are available for the products demanded, and (4) the ceterus paribus concept of a normal demand curve exists. The constant marginal utility of money allows a cardinal measure to be established for the various components of net social benefits. The presence of any income effect causes overestimation of the total social benefits by the amount of the income effect--thus, the area under the demand curve is only an approximation of social benefits. The last two assumptions allow social benefits to be a finite quantity and to be measured irrespective of conditions and changes outside the sector being analyzed.

Tweeten and Tyner (18) point out additional assumptions that pose limitations to the use of these welfare concepts in agricultural policy. The assumptions that knowledge is complete, that products and resources are perfectly mobile and that the initial resource distribution is optimal are discussed (18,

p. 37). The interested reader should refer to their article for details.

Notwithstanding these limitations, estimates of net social benefits are easily computed from the quadratic programming model and will be presented later in this paper. Some of the limitations are avoided by considering changes in net social benefits between the benchmark situation and another. Even though the exact magnitudes of the welfare estimates may be questioned, the direction of the changes may still be a useful guide for public decision making.

F. AGSEM Testing and Validation

AGSEM represents the operating analysis system resulting from experience gained from the Prototype Quadratic Programming Model reported by Miller and Millar (12). Initially the 1973 benchmark case and the four exogenous shocks or changes evaluated by the prototype model were also evaluated via AGSEM. In later tests using 1976 data, over 40 additional situations were evaluated and the nature and magnitude of the response in key variables checked for reasonableness. The tests proved AGSEM to be flexible and convenient in manipulation and application, efficient in computation and effective in providing consistent estimates of the inpacts of a wide range of exogenous changes. Results of one set of these tests are presented in the next section.

IV. EVALUATION OF PARITY

To demonstrate the capability of the model, questions resulting from the current issue of parity prices were chosen for analysis. This analysis serves a twofold purpose: (1) it demonstrates the type of information generated by the model and (2) it provides impact estimates that can be checked for validity against a current ESCS analysis (4).

Parity prices may be reached by several different means, including (1) restrictive marketing quotas and allotments, (2) CCC nonrecourse price support

loans, (3) deficiency or incentive payments, (4) legislated fixed price minimums, and (5) direct government purchases of agricultural commodities. The impact of achieving parity prices by the first and fifth of those methods were estimated by AGSEM.

Note that these analyses are based on the assumption that 1976 production, prices, and consumption patterns represent a basic equilibrium situation for the U.S. agricultural industry (Model A) and that an exogenous event (a parity price program) moves this equilibrium to a new point (Models B, C, D and E). The rationale behind this procedure is based on the belief that changes in the equilibrium caused by a specific price change would be essentially the same, whether they occur in 1976 or in some other year. An important advantage of this procedure is that the model results are unencumbered by errors in projections of coefficients to some future period.

In accordance with this procedure, the 1976 "corresponding parity price" was defined for each farm product group (table 1). The corresponding parity price in table 1 bears the same relationship to the 1976 benchmark (actual) price as the official USDA December 1977 parity price bears to actual 1977 prices received by farmers. For example, farmers received $2.27 for wheat during 1977 while the December 1977 parity price was $5.05 per bushel--a price difference of $2.78 per bushel. In terms of the 1977 AGSEM benchmark wheat price of $3.12, a price increase of this magnitude results in a 1976 corresponding parity price of $5.90. The prices shown in the last column of table 1 were thus used in the following analysis.

A. Direct Government Purchases of Agricultural Commodities

Direct government purchases to achieve 100 percent parity price levels were analyzed for (a) all agricultural crops and livestock products and (b) for the seven program crops, wheat, corn, sorghum, barley, oats, soybeans and cotton. Direct government purchases of agricultural commodities and livestock were

Table 1. 1977 price received and parity prices and computation of 1976 AGSEM corresponding parity prices

Farm Product	Unit	1977 Price received	1977 December parity price	1977 Required increase	1976 AGSEM Price received (Benchmark)	1976 AGSEM Corresponding parity price
Wheat	$/bu.	2.27	5.05	2.78	3.12	5.90
Feed grains	$/T.	72.64	121.94	49.30	85.64	134.94
Other crops	Index	238.5	291.6	22.2%	100.0	122.2
Fruits and vegetables	Index	179.7	237.0	31.9%	100.0	131.9
Livestock	Index	175.0	268.2	53.3%	100.0	153.3
All products	Index	182.3	275.3	51.0%	186.0	--

assumed to prevent these goods from ever entering either domestic or foreign markets. The analysis does not specifically consider questions concerning the storage or disposal of these government purchases of agricultural commodities.

100 Percent Parity Prices for All Agricultural Products - Model B

Approximately $39 billion worth of agricultural commodities must be purchased by the government to achieve 100 percent parity prices for all agricultural products. Approximately 1.7 billion bushels of wheat and 4.7 billion bushels of feed grains are purchased annually. In dollar terms, wheat purchases amount to $9.89 billion, feed grain purchases are $15.97 billion, fruits and vegetables $1.38 billion, and livestock and livestock products purchases equal $11.65 billion. No purchases are required of other crops because parity prices cause these crops (primarily soybeans and cotton) to lose their comparative advantage which results in a production decrease large enough to achieve parity prices in the marketplace.

Direct government purchases have the impact of stimulating production in the other product categories, as shown in table 2. Wheat and feed grain production increase 33 and 37 percent, respectively. Other crop production decreases by 28 percent because of larger relative price increases in feed grains and competition for cropland. Fruit and vegetable and livestock production increase 6 and 8 percent respectively, based on published supply elasticities for these crops in relationship to respective price increases.

Table 3 shows the impact of parity prices on farm income components. Farm operating expenses increase approximately 30 percent while cash receipts from farm marketings increase over 60 percent. Increased feed purchases account for approximately one-half of the increase in farm operating expense. At the same time, livestock marketings contribute to one-half of the increase in total cash receipts. Realized net farm income would triple over benchmark levels.

Table 2. Production effects with all agricultural commodities at 100 percent parity prices

Production	Unit	Model A 1976 level	Model B Parity level	Percent Change
Wheat	mil. bu.	2,147.4	2,854.	32.9
Feed grains	mil. T.	212.4	290.1	36.6
Other crop	1976=100	100	72.00	-28.0
Fruits and vegetables	1976=100	100	106.38 1/	6.38
Livestock	1976=100	100	108.30 1/	8.30

1/ Maximum increase was determined exogenously from supply response data and limited in AGSEM by appropriate activity bounds.

Table 3. Summary of farm operating expense and cash receipts and farm income effects with all agricultural commodities at 100 percent parity prices.

Item	Model A 1976 level	Model B Parity level	Change
	(million dollars)	(million dollars)	(percent)
Operating Expense			
Hired labor	6,996.7	8,713.6	+ 24.5
Feed purchased	11,082.2	18,759.4	+ 69.3
All other expenses	38,409.9	45,808.2	+ 19.3
Total	56,488.9	73,281.2	+ 29.7
Cash Receipts			
Wheat	6,214.6	15,481.1	+149.1
Feed grains	13,584.6	29,000.3	+113.5
Other crops	16,468.3	17,289.8	+ 5.0
Fruits & veg.	12,086.0	16,961.1	+ 40.3
Livestock	46,478.3	77,006.8	+ 65.7
Total	94,832.1	155,739.2	+ 64.2
Realized Net Farm Income	20,389.2	64,504.0	+216.4

As shown in table 4 food prices paid by consumers would increase by over 16 percent with the biggest increase of 23 percent coming in livestock products. Domestic food consumption decreases by about 4 percent in adjustement to these price increases. These estimates are based on the assumption used in AGSEM that marketing margins hold constant in dollar terms independent of the level of prices.

The export demand elasticities used in this analysis are based on the procedure suggested by Johnson (8). These elasticities represent the well known elasticity of excess demand except that a constant elasticity specification has been used to provide increased exports at higher prices. Basically U.S. grains would become noncompetitive in world markets. Agricultural exports would decline in both quantity and value. With U.S. exports at parity prices the rest of the world would become nearly self-sufficient in wheat and food grains as shown in table 5. Wheat exports would fall by about 90 percent to about 96 million bushels and feed grain exports would fall by nearly 90 percent to 6 million tons. The total dollar volume of all agricultural exports would decline by over 50 percent to approximately $11 billion per year. This loss of approximately $12 billion in the volume of U.S. agricultural exports is certainly one of the more important impacts of domestic prices at 100 percent parity. It contrasts sharply with the $7 billion increase estimated by ESCS (4, page 8). This difference will be discussed in detail later in this paper.

Limiting Parity Price Purchases to Seven Program Crops - Model C

Government purchases of $28 billion would be required to achieve parity prices for the seven program crops (Model C), compared to $39 billion for all agricultural commodities. Approximately 1.7 billion bushels of wheat and 132 million tons of feed grains would be purchased to balance the market at parity prices. AGSEM results suggest that the prices of soybeans and cotton would be pushed to parity levels without substantial government purchases due to farmers'

Table 4. Summary of consumer price effects with all agricultural commodities at 100 percent parity prices.

Item	Model A 1976 level	Model B Parity level	Percent Change
		----1976=100----	
Grain mill & bakery products	100.0	109.7	9.7
Livestock products	100.0	123.2	23.2
Other foods	100.0	108.2	8.2
All farm foods	100.0	116.4	16.4

Table 5. Summary of export volumn and value effects with all agricultural commodities at 100 percent parity prices

Export product	Model A 1976 volume	Model B Parity volume	Change	Model A 1976 value	Model B Parity value	Change
	(millions)	(millions)	(percent)	(million dollars)	(million dollars)	(percent)
Wheat	1020.4 bu.	95.6 bu.	-90.6	4115.9	614.9	-85.1
Feed grains	56.8 Ton	5.75 Ton	-89.9	6062.5	892.7	-85.3
Other exports (raw)	N/A	N/A	N/A	5934.6	2,400.7	-59.5
Processed exports	N/A	N/A	N/A	7032.9	7,180.	+2.1
Total exports	N/A	N/A	N/A	23146.0	11,088.4	-52.1

shifting production to the relatively better priced wheat and feed grains.

The production effects of supporting the seven program crops at parity prices are similar to those shown in table 2 for wheat, feed grains, and other crops. Since fruits and vegetables are not supported in Model C, they show some small decrease in production and livestock and livestock products decrease about 3 percent due to higher feed costs incurred and lower profitability in this sector.

Table 6 summarizes the impact of supporting the prices of seven crops at parity levels on farm operating expenses, cash receipts, and farm income. This table contrasts in several important ways from table 3 which showed similar data when all agricultural commodities were supported at parity prices. In Model C current farm operating expenses increase by approximately 15 percent, composed mostly of increased costs of purchased feeds. Cash receipts from farm marketings increase by approximately 30 percent, composed mostly of increases in wheat and feed grains sales. Compared with table 3, the increase in cash receipts is approximately $33 billion less when livestock are not included in the parity support program. As a result, net farm income increases approximately $20 billion when seven crops are supported as compared to a $44 billion increase when all agricultural commodities are supported at parity levels.

It is interesting to note that the increase in net farm income is approximately $7 billion less than the cost of commodity purchases by the federal government. This paradox arises because livestock enterprises would become much less profitable with increased feed costs. Probable results of this situation would be less grain fed beef available for the market. It is likely that younger animals would be slaughtered or be held on the range for a longer period of time before moving to feedlots. AGSEM, however, is unable to provide much detail about the mix of fed versus non-fed beef because of the high level of aggregation used.

Table 6. Summary of farm operating expense, cash receipts and farm income effects with the seven program crops at 100 percent parity prices

Item	Model A 1976 level	Model C Parity level	Change
	(million dollars)	(million dollars)	(percent)
Operating Expense			
Hired labor	6,996.7	6,023.5	-13.9
Feed purchased	11,082.2	16,760.1	+51.2
All other expenses	38,409.9	42,063.9	+9.5
Total	56,488.9	64,847.6	+14.8
Cash Receipts			
Wheat	6,214.6	15,481.1	+149.1
Feed grains	13,584.6	28,923.6	+112.9
Other crops	16,408.3	16,989.6	+3.2
Fruits & veg.	12,086.0	11,678.3	+3.4
Livestock	46,478.3	50,641.1	+8.9
Total	94,832.1	123,713.9	
Net Farm Income	20,389.2	40,912.3	+100.6

Compared to the 16.4 percent increase in food prices estimated by Model B in table 4, food prices would be expected to increase only 4.6 percent with seven program crops supported at parity price levels. Grain mill and bakery product prices increased 9.4 percent, livestock products 5.5 percent, and other food products only 1.2 percent. This moderation in the increase in consumer food prices from 16.4 percent to 4.6 percent represents a very important effect of limiting parity price support to the seven program crops. Certainly the narrower parity price support program would be much more acceptable to consumers.

The impact on agricultural exports with seven program crops at parity prices is essentially the same as when all agricultural commodities are supported (discussed earlier in table 5). Since the seven program crops compose a majority of the U.S. agricultural exports, and since the processed export category is not very responsive to farm level prices, exports still decline by approximately $11 billion, even when support operations are limited to the seven program crops.

Whether the direct government purchase program covers seven crops or all agricultural production, net returns to cropland would be expected to increase by 90 to 190 percent in various U.S. production regions. The largest increases would be expected in the wheat areas. Much of this increase would be capitalized into land values, depending to a great extent on the perceived permanency of the Government purchase program and the expectations of land purchasers.

The impacts discussed here are for one year only, in general an average year during the first four years of such a Government price support program. Similar costs and outcomes would be expected to occur every year such a program was operative. For example, although the analysis avoided consideration of issues involved in storing and disposing of Government commodity stocks, it does suggest that the cost of storing grain would amount to $1.5 billion in the first year. Such costs would be expected to continue building as successive years'

crops were purchased and stocks continued to build. This result is inescapable with a Government purchase program, since U.S. agriculture has a considerable excess capacity at parity price levels--an excess capacity that is estimated by the $39 billion (or $28 billion) level of direct Government purchases. This treasury outlay, and the additional accumulating cost of storing and disposal of farm commodities, necessitate consideration of some other measure of supportive farm prices. The next section will consider an alternative Government program, restrictive marketing quotas and allotments.

B. Restrictive Marketing Quotas and Allotments

Marketing quotas or allotments on U.S. agricultural commodities could be administered either by the USDA or by a National Agricultural Board of producer representatives as proposed by the American Agriculture Movement. This section evaluates the use of such quotas and allotments to achieve parity prices, first for all agricultural commodities and then for the seven program crops. Questions concerning the administrative cost of such quotas and allotments were not considered by this analysis. Further, the analysis does not distinguish between restrictions on sales (marketing quotas) and restrictions on production (acreage allotments) since in equilibrium these two types of controls have identical impacts.

<u>100 Percent Parity Prices for All Agricultural Products - Model D</u>

Because of the different levels of marketing demand for different crop and livestock products and because of complex interrelationships between products at the farm level, a wide range of different restrictions are required to balance production and consumption at parity prices. Table 7 shows that wheat production must be restricted by 45 percent, feed grain production decrease 29 percent, and other field crops decreased 24 percent. Fruit and vegetable production prices. The [illegible]

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Table 7. Summary of production effects with marketing quotas and allotments to achieve 100 percent parity prices for all agricultural products.

Item	Level unit	Model A 1976 level	Model D Parity level	Percent Change
Wheat	Mil. Bu.	2,147.4	1,178.9	-45.1
Feed grains	Mil. tons	212.4	151.0	-28.9
Other crops	Mil. dol.	16,261	12,374.6	-23.9
Fruits & veg.	Mil. dol.	12,086	11,827.0	-2.1
Livestock	Mil. dol.	46,389	42,688.0	-8.0

and livestock production would be restricted by 2 and 8 percent, respectively. This production cutback would necessitate idling approximately 115 million acres of cropland. This amount of idle acreage is substantially larger than estimated in other analyses of parity prices (4, p. 14). Wheat producing areas would require the most radical acreage cutbacks.

The AGSEM computer model allows easy experimentation in evaluating the impact of different levels of marketing quotas and allotments. At the planning phase of this study, it was expected that the appropriate quotas could be easily identified by looking at the excess production capacity under the Government purchase program and by making a few trial and error adjustments between production classes until all products reach parity price levels. However the process of choosing national quotas for separate product categories to force prices up to the parity level proved to be extremely complex. Interrelationships between crops on the farm level cause many unexpected price impacts. The process turned out to be a complex trial and error procedure and numerous computer runs were required to restrict production in the appropriate manner so that all prices would approximate parity levels without unanticipated shortages for some products. The difficulty encountered is mentioned here because it suggests the overwhelming administrative difficulty that would be faced in operating such a program for all farms and all commodities. Given the stochastic elements in both production and final demand, it would be impossible to duplicate these results in the real world. Rather, some combination of marketing quotas and direct government purchases would be required to (a) achieve parity price levels and (b) assure enough production that substantial shortages did not accidently occur for some products. Even then the task of setting a quota for every crop on every farm of the U.S. would be substantial. Given that the quotas are so low and that the economic incentive for exceeding these quotas would be substantial, enforcement may be impossible. Other evaluations of the program (see reference 4)

have either minimized or omitted entirely any discussion of this difficulty.

Compared to the Government purchase program analyzed earlier, the market quota program shows a decrease in farm operating expense of over 12 percent, as shown in table 8. This decline in expenses is led by hired labor, which decreases 54 percent as a result of the substantial cutbacks in grain production. The feed purchase category increases by almost 41 percent. Cash receipts from farm marketings increased by 24 percent. All categories except other crops show increases in cash receipts. Livestock show the largest percentage increase of 40 percent, suggesting that livestock and livestock producers are able to pass much of the increased feed costs on to consumers. Net farm income increases $30 billion to 140 percent of the baseline level. This figure compares to the $44 billion increase shown in table 3 resulting from a government purchase program supporting all agricultural commodities at parity prices.

The effects of marketing quotas to achieve parity prices for all agricultural products on food prices and on the export market is almost identical to the direct government purchase program discussed earlier (see tables 4 and 5). Under both programs farm products enter the marketing and export channels at parity price levels and affect the remaining sectors identically. Beyond the farm gate the only significant difference is the extreme government stock buildup described earlier under the government purchase program.

Marketing Quotas for the Seven Program Crops - Model E

To achieve parity prices for the seven program crops, production cutbacks of 45 percent for wheat, 25 percent for feed grains, and 15 percent for other field crops would be required. These results are not substantially different from those shown in table 7. The non-parity categories of fruits and vegetables and livestock would not be subject to marketing quotas; however livestock production would decline 2 percent under this program because of the

Table 8. Summary of farm operating expense, cash receipts and farm income effects with marketing quotas and allotments to achieve 100 percent parity prices for all agricultural products.

Item	Model A 1976 level	Model D Parity level	Percent Change
	(million dollars)	(million dollars)	
Operating Expense			
Hired labor	6,996.7	3,226.6	-53.9
Feed purchased	11,082.2	15,939.7	+43.8
All other expenses	38,409.9	30,126.8	-21.6
Total	56,488.9	49,293.1	-12.7
Cash Receipts			
Wheat	6,214.6	6,394.7	+2.9
Feed grains	13,584.6	15,096.5	+11.1
Other crops	16,468.3	15,127.9	-8.1
Fruits & veg.	12,086.0	15,602.3	+29.1
Livestock	46,478.3	65,432.2	+40.7
Total	94,832.1	117,653.6	+24.1
Net Farm Income	20,389.2	50,406.5	+147.2

adverse effect of high feed grain prices. In total, nearly 97 million acres of cropland would be idled in achieving parity prices for the seven program crops. This idle land would be concentrated in the wheat and feed grain areas--again roughly one of every two acres of wheat would be idled.

The marketing quota program for the seven major crops results in a 5 percent decrease in operating expenses and an increase in net farm income of 32 percent or nearly $7 billion as shown in table 9. Cash receipts from feed grain marketings account for most of the increase in cash receipts and the comparison between feed purchased and livestock receipts suggests that the livestock sector would be significantly less profitable. These increased feed costs would likely cause a severe reorganization of the cattle feeding industry.

A marketing quota program covering the seven major program crops would increase food prices approximately 3 percent, similar to the increase discussed earlier for the Government purchase program covering the seven program crops. The value of agricultural exports would decline to $12.8 billion under this program. As with the other three programs analyzed, the wheat and feed grain export market is adversely affected by parity prices for the seven program crops.

C. Questions Concerning Export Demand Elasticities

The above estimates of the value and quantity of U.S. agricultural exports under programs to raise farm prices to parity levels show rather extreme differences when compared to published USDA estimates (4, pp. 8-11). While AGSEM estimates the value of U.S. agricultural exports at $11 to $12 billion under parity prices, official USDA estimates are in the neighborhood of $29 to $32 billion (4, table 6). This approximately $20 billion difference in the estimates stems from the differences in the elasticities in demand assumed for U.S. agricultural exports. The importance of these differences suggests that [illegible] would be concentrated [illegible]

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Table 9. Summary of production effects with marketing quotas and allotments to achieve 100 percent parity prices for seven program crops.

Item	Model A 1976 level	Model E Parity level	Percent Change
	(million dollars)	(million dollars)	
Operating Expense			
Hired labor	6,996.7	3,545.2	-49.3
Feed purchased	11,082.2	16,910.9	+52.6
All other expense	38,409.9	33,101.6	-13.8
Total	56,488.9	53,557.7	-5.2
Cash Receipts			
Wheat	6,214.6	6,394.7	+2.9
Feed grains	13,584.6	15,924.6	+17.2
Other crops	16,468.3	15,925.0	-3.3
Fruits & veg.	12,086.0	11,120.5	-8.0
Livestock	46,783.3	49,183.4	+5.1
Total	94,832.1	98,548.3	+3.9
Net Farm Income	20,389.2	27,036.6	+32.6

the export demand elasticities should be closely scrutinized.

The impact of export demand elasticities on the parity price question is clear. If the overall demand for U.S. agricultural exports is elastic, the increased domestic prices would result in substantial declines in both the quantity and value of U.S. agricultural exports. Current balance of payments problems would be substantially worsened. The products normally flowing into export markets would have to be either absorbed by the Government purchase program or forced out of production through an extremely restrictive marketing quota system. On the other hand, if the elasticity of demand for U.S. agricultural exports is relatively low, export quantities would tend to be maintained under domestic parity level prices and the total value of exports would increase. The balance of payments situation would be improved substantially and a smaller burden placed on a Government purchase or marketing quota program. Treasury outlays would be lessened. As a result, the overall impact (and possibly even the feasibility) of a parity price program critically depends on the elasticity of demand for U.S. agricultural exports.

Export demands used in AGSEM up to this point in Models A through E are based on the well known concept of excess demand as discussed earlier in section III-D. The elasticities of excess demand that result from this procedure are presented in the first column of table 10. These elasticities are in agreement with those computed by Johnson (8) and, while based on a slightly different procedure, also agree with the estimates of Tweeten (17). They are relatively high because even though U.S. exports are large, they are still a relatively small proportion of total world production and consumption. Thus, as U.S. prices increase, adjustments in production and consumption in the rest of the world rapidly diminish the role of U.S. exports.

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Table 10. Export demand elasticity estimates for U.S. agricultural products

Export product	Elasticity of excess demand 1/	Elasticity of demand 2/
Wheat	-5.0	-0.4
Feed grains	-6.0	-0.4
Other farm prod.	-4.2	-0.5
Food products	-1.0	-0.6
Average for all products	-3.84	-0.49

1/ Used for Models A, B, C, D, and E.

2/ Used for Models B', C', D', and E'.

The elasticity estimates shown in the second column of table 10 are consistent with the results of the USDA report (4). Since demand here is assumed to be inelastic, an increase in U.S. prices results in a slight decrease in export quantities but a substantial increase in the value of exports. If these elasticities exist, it would pay the U.S. to unilaterally increase the price of exports as a means of increasing the dollar value of exports. Such is the case of a seller exploiting an inelastic demand under imperfectly competitive situations. To thoroughly evaluate the implications of these elasticities on the parity question, the AGSEM evaluations discussed earlier were repeated with the more inelastic export demand relationships--Models B', C', D' and E'.

Table 11 presents the effects of the lower export demand elasticity on the value and quantity of U.S. exports under the program supporting all commodities at parity levels through marketing quotas and allotments. The results shown in the last two columns of the table are much more consistent with other USDA evaluations. In value terms all categories increase, led by wheat and feed grains. The total value of exports increases to $27.2 billion or nearly 18 percent. This compares with a decrease of nearly 50 percent under the original elasticities. In quantity terms, both wheat and feed grains exports decline nearly 90 percent under the original excess demand elasticity assumptions but decline only 17 and 12 percent respectively under the inelastic export demand situations.

The effects of the assumed export demand elasticities go farther than the foreign trade impacts. In terms of implementing a parity program by either direct Government purchases or marketing quotas and allotments, the elasticity estimates of export demand will seriously influence the results. Table 12 suggests that the cost of a Government purchase program is about $14 billion lower if export demand is inelastic. Under the marketing quota allotment program, the idle acreage needed to balance supply and demand at parity prices is also substantially different. To support all products at parity prices,

Table 11. Effect of export demand elasticity on the value and quantity of U.S. exports--all commodities supported by marketing quotas and allotments

Export product	Model A 1976 level	Original AGSEM estimates		With inelastic export demand	
		Model D Level	Percent change	Model D' Level	Percent change
Value of exports (mil. Dol.)					
Wheat	4,115.9	614.9	-85.1	5,436.6	+32.1
Feed grains	6,062.5	892.7	-85.3	7,794.1	+28.6
Other farm products	5,934.7	2,861.7	-51.8	6,443.7	+8.6
Processed products	7,032.9	7,240.8	+3.0	7,548.6	+7.3
Total	23,146.0	11,610.1	-49.8	27,222.9	+17.6
Quantity of exports					
Wheat (mil. bu.)	1,020.4	95.6	-90.6	845.5	-17.1
Feed grains (mil. T.)	56.8	5.7	-89.9	50.2	-11.7

Table 12. Importance of export demand elasticities on government actions required to achieve parity level prices

Item	Unit	Original AGSEM estimates	With inelastic export demand
Cost of government commodity purchases			
All products supported	Bil. $	38.9	24.4
7 program crops supported	Bil. $	27.7	13.7
Cropland idled under marketing quota/allotment program			
All products supported	Mil. Ac.	115.6	34.0
7 program crops supported	Mil. Ac.	96.6	17.8

the idle land requirement is reduced from 116 million acres to 34 million acres. If only seven program crops are supported, idle land is reduced from 97 million acres to 18 million acres. The magnitude of these differences appear quite significant both in terms of Government costs and in terms of the rigor of the required supply control. These differences may mean the difference between a policy that is acceptable to consumers and farmers and a policy that is unacceptable. The export demand elasticity for U.S. agricultural products is a key variable determining whether parity level prices would be an acceptable policy for U.S. agriculture.

Unfortunately, econometric techniques and economists in general have not provided clear signals as to actual export demand elasticities. The notion of an export demand function and its elasticity is itself an abstraction. There are persuasive arguments to the idea that U.S. exports and the nature of international trade in general is set through negotiations, agreements and political pressures and is not price responsive in the short run. There is also an uncomfortable question concerning the economic length of run in sector models like AGSEM as compared to the calendar time dimension of the official USDA estimates. Nevertheless, the extreme importance of estimates of export market response to many domestic policy questions dictates that attempts should be made to clear up the confusion in this area.

D. Changes in Welfare Components

As was discussed in section III-E, quadratic programming provides a means of making empirical estimates of total social benefits, social costs, and net social benefits under alternative policies. These measures provide an interesting contrast between the impact of achieving parity prices through a Government purchase program and the use of a quota or allotment program to achieve the same goals.

Table 13 shows the changes in the various benefit and cost categories under the two major programs evaluated. The table is separated into three categories: (a) social benefits, which are the areas under the respective demand curves, (b) social costs, which are the areas under the input supply curves plus the costs of the production activities, and (c) net social benefits, which is defined as the difference between benefits and costs or alternatively the area under the demand curve and above the supply curve. Figure 3 provides a convenient way of seeing the relationships between the different components. In the benchmark situation, social benefits would be represented by the area under the demand curves or areas j, k, and l, social costs would be represented by area l, and net social benefits by areas j (consumer surplus) and k (producer surplus).

Under a direct Government purchase program to increase prices (Model B), the quantity purchased by the Government is represented by area MNOR in the middle figure. This value of this quantity is $38.9 billion shown in the first column of table 13. Total social benefits are now area j plus area PNOQ and have increased $12.2 billion over the benchmark situation. Area j has decreased by $26.7 billion. Area l, social costs, have increased $10.8 billion as shown in table 13. Net social benefits are still represented by areas j and the expanded area k (now PNT) in the middle figure. The domestic consumer surplus has decreased $32.4 billion, the export consumer surplus has decreased $4.9 billion, and the producer surplus has increased $38.7 billion.

In summary, a direct Government purchase program results in a substantial transfer of surplus from the consumer sector to the producer sector. It appears that the gain in producer surplus is approximately equal to the cost of the government purchases in this case. However the decrease in domestic consumer surplus is substantial (as was suggested earlier in discussing increased food prices). A final issue in this program is the $38.9 billion cost to the taxpayers.

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Table 13. Changes in social costs and benefit categories under alternative means

	Model B Direct government purchases	Model D Marketing quotas/ allotments
Social Benefit Changes		
Domestic demand	-10.5	-10.5
Export demand	-16.2	-15.0
Subtotal	-26.7	-25.5
From government purchases	+38.9	--
Total change	+12.2	-25.5
Social Cost Changes		
Production	+18.8	-0.5
Marketing and export	-8.0	-7.7
Total change	+10.8	-8.2
Net Social Benefit Changes		
Domestic consumer surplus	-32.4	-30.0
Export consumer surplus	-4.9	-4.4
Agricultural sector surplus	+38.7	+17.1
Total change	+1.4	-17.3

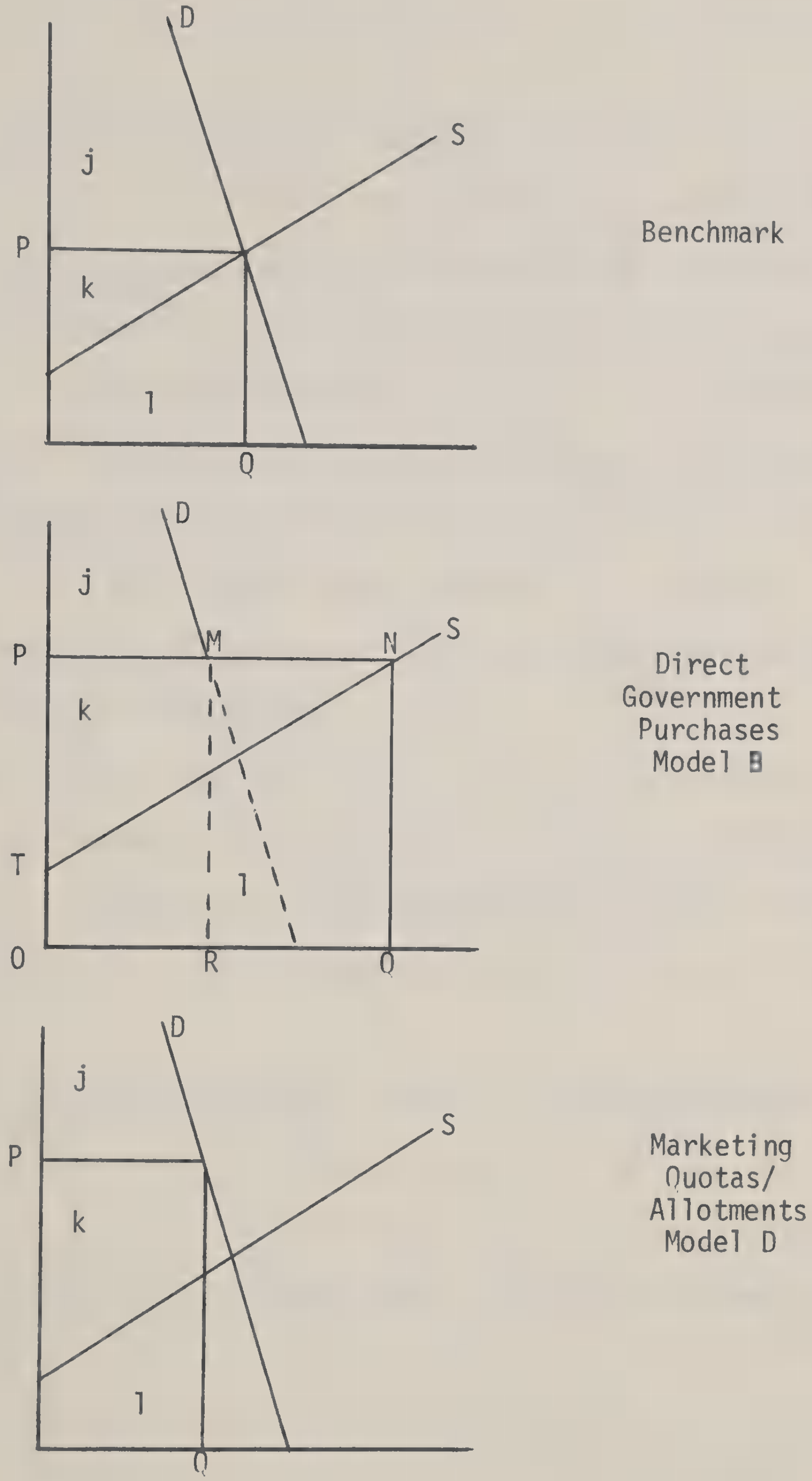

Figure 3. Social benefit and cost components under alternate means of achieving parity prices.

Society must make the choice on the basis of whether or not a transfer of benefits from consumers to producers is worth the taxpayer cost of $39 billion per year.

A marketing quota allotment program theoretically reaches the same price level but provides a much different distribution of social benefits and costs. As shown by the lower graph in figure 3, production is now restricted to level Q. Since a parity price level is reached, the decrease in area j and the decrease in consumer surplus is approximately the same as for the direct Government purchase program. However, social costs now decrease, that is area l becomes smaller by $8.2 billion. Area k, which represents the agricultural sector surplus, increases $17.1 billion over the benchmark level. There is no government cost to such a program and net social benefits (areas j plus k) decreases by $17.3 billion as shown in table 13.

This program also transfers benefits from consumers to producers. However, consumers give up more than producers gain due to the loss in efficiency caused by forcing the sector to operate short of the most efficient equilibrium level. The advantage, of course, is that no direct cost to the government results under this program.

Table 13 and figure 3 are presented here to illustrate one of the capabilities of AGSEM. For many analyses, these measures can play a key role in defining issues and understanding the nature of the results. Since the report writer capability in AGSEM automatically prints table 13-type data for each model situation, comparisons of this type can be easily made.

V. SUMMARY AND CRITIQUE OF AGSEM CAPABILITIES

The AGSEM model provides estimates of the relative impacts of various exogenous events upon various components of the food and fiber industry. Its

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greatest strength lies in the extremely wide range of exogenous events that it is capable of analyzing. The situation evaluated in this paper is only suggestive of the model capability--it by no means explores the range of this capability. Exogenous factors that are potential candidates for analysis include most major physical and economic variables within the input, production, marketing, and export sectors of the U.S. food and fiber industry.

The relative impacts of such events may also serve as useful indicators in setting research priorities and in focusing the attention of specific research activities. Since the impacts are presented in terms of key economic indicators--net farm income, food prices and expenditures, exports, and net consumer and producer benefits--such evaluations are useful in both identifying topics for in-depth research and in pointing out the nature and possibilities of problems developing within the agricultural sector.

In terms of the mission of the Agricultural Policy Analysis program area, AGSEM can make a contribution to two research areas. First, the ability to provide empirical estimates and manipulation of social benefits, costs, and surplus components relating to welfare economics should be a useful component of the rationale project. While the rationale project as currently described is not primarily a quantitative exercise, some quantification may be useful. The ability of AGSEM to identify relative impacts and tradeoffs may be of considerable use to the project. Secondly, AGSEM is viewed as one of the tools for the production adjustments research project. With the development of more predictive models for evaluating production adjustments, AGSEM can take its place (along with POLYSIM) as a means of tracing impacts within an internally consistent and complete model of the agricultural sector. However since a competitive equilibrium model like AGSEM is suggestive but not necessarily predictive, other predictive techniques must provide the core activity of the production adjustments modeling.

A number of limitations concerning the model and procedure have been discussed in detail earlier in this paper. However they should be summarized at this point since they are predominant factors influencing the use and interpretation of AGSEM results. Many problems result from the use of a static equilibrium model and the limitations of such a model. The real world is seldom, if ever in equilibrium. Rather it makes continuous adjustments towards a theoretical, but constantly shifting, equilibrium point. The assumption that a current benchmark year represents an equilibrium is an extreme simplification.

In addition, the agriculture industry of the U.S. generally does not make simultaneous adjustments to supply and demand forces. Rather, it follows a "cobweb-type" response path where future production decisions for most commodities are based significantly on current prices. The use of a static equilibrium model only provides estimates of the direction of the eventual change. Such estimates are generally not indicative of the first-year response to the same external forces in the real world. There is always an unanswered question of how long it would take for the economy to reach the equilibrium estimated by the model, if in fact that equilibrium is obtainable.

To diminish the severity of these limitations, AGSEM has been constructed and used in a mode that estimates the <u>shift</u> caused in the equilibrium point by various exogenous events. The model is useful to the extent that the estimated shifts in equilibrium point are indicative of the actual impact of those exogenous events in the real world. Even here the highly aggregate nature of the model itself means that it provides only marginal accuracy for specific components While AGSEM provides some suggestion of relationships between commodities, a more detailed commodity specification would be necessary to thoroughly evaluate specific commodity questions.

As a final limitation, readers should keep in mind that the welfare measures of limitations concerning the model and [illegible] have

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diminish the severity of [illegible] [illegible] [illegible] each [illegible] [illegible]

mode that estimates the shift cause [illegible] the equilibrium [illegible] [illegible]

vents. The model is useful to the extent [illegible] estimated shift

[illegible] point are indicative [illegible] the actual [illegible]

[illegible] world. Even here the highly aggregate nature of the model itself

[illegible] provides only marginal accuracy for specific component, while

[illegible] suggestion of relationships between commodities, [illegible] more [illegible]

[illegible] specification would be necessary to thoroughly evaluate specific

[illegible] tion. Readers should keep in mind that the welfare measures estimated at the end of this paper are somewhat controversial and have been abandoned by some economists (10). Nevertheless, optimal policy decisions for society require some implicit or explicit welfare basis. The estimates of welfare tradeoffs from AGSEM may be suggestive of the actual impact on society's general welfare. In interpreting the results it may be useful to consider the estimated welfare changes as hypotheses. In cases where these hypotheses are obviously undesirable, in-depth research may be warranted to reject them. If such hypotheses cannot be rejected, it would appear appropriate to bring them to the attention of policymakers.

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Appendix A: Data Base: Organization and Description

AGSEM is a complete analysis system made up of (1) a data base, (2) a matrix generator that forms mathematical programming models out of this data base, (3) an optimization routine that solves these models, and (4) a report writer that computes output based on the data, model coefficients or solutions. Appendix A presents the organization and description of the first of these four components, the data base.

To facilitate "hands-off" construction of models via a matrix generator, the data base must be organized and identified in a formal manner. Data is contained in Tables, which have specific Table names. Within tables, individual table elements are located by row and column codes. Sets of similar codes make up lists. Dictionaries are used to keep track of lists.

When a model is constructed, classes of activities and constraints are first defined and given specific identifiers. All model coefficients are then identified by combinations of these identifiers and the table row and column codes described in the previous paragraph. For example, a crop production activity in AGSEM, identifier (c) for the production of wheat (WH) in the dryland areas of the West (R1) covers the specific name (CWHR1) in accordance with the procedure described in the following Exhibits, A-1, A-2, and A-3. The size of the basic AGSEM matrix is 20 constraints and 187 activities as shown by Exhibit A-4.

Appendix A: Data Base: Organization and Description

computerized model ...

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Exhibit A-1

Dictionary Name	List name	Item	Item code
Farm Inputs	ii	Labor Other Operating Input Expenses	LA OI
Crop Production	pp	Wheat Feed Grains Other Crops Fruits & Vegetables	WH FG OC FV
Livestock Production	ll	Livestock, total	LT
Domestic Products	dd	Grain, Mill & Bakery Products Livestock Products Other Food Products Non-Food Products	GB MD OF NF
Export Products	ee	Wheat & Wheat Products Coarse Grains Other Farm Products (raw) Food Products - Processed	WE CG OE PE
Demand Steps	nn	Demand Function Steps (even)	01 02 ⋮ nn
Supply Steps	ss	Supply Function Steps (odd)	01 02 ⋮ ss
Production Response	ff	Production Flexibilities	01 02 ⋮ ff
Regional Production Areas	Rr	West-Dryland West-Irrigated Corn Belt and Northeast States Southeast and Delta States	R1 R2 R3 R4

Exhibit A-2

Activity Classes:

Class	Definition	Identifier and Name
1. Input supply	Supply farm input ii by supply fm step ss	Iiiss
2. Crop production	Produce crop pp on land type Rr	CppRr
3. Production flexibilities		pprff
4. Stock management and transfer	Add to stock of crop pp from crop pp	Spppp
5. Livestock production	Produce livestock ll	Lll
6. Domestic marketing	Manufactor domestic product dd.	Mdd
7. Export marketing	Ready product ee for export	Xee
8. Domestic demand	Demand domestic product ddfn step nn.	Dddnn
9. Export demand	Demand export product ee fc step nn.	Eeenn

Exhibit A-3

Constraint Classes:

Class	Definition	Identifier and Name
1. Land restraints	Land restraint region r	Rr
2. Farm input balances		Pii
3. Crop supply and utilization		Upp
4. Livestock product balance		Vll
5. Domestic product		Bdd
6. Export product balances		Bee

Exhibit A-4

Activity Classes	Number	
1. Farm input supplies	18	
2. Crop production activities	11	
3. Production flexibilities	50	
4. Stock management and transfer activities	3	Total Activities
5. Livestock production activities	1	187
6. Domestic marketing	4	
7. Export marketing	4	
8. Demand for domestic products	48	
9. Demand for export products	48	

Constraint Classes		
1. Land restraints	4	
2. Farm input balances	2	
3. Crop supply and utilization	4	Total Constraints
4. Livestock product balance	1	20
5. Domestic product balances	4	
6. Export product balances	4	
7. Objective--row	1	

Five main categories of data are required to support the model:

1) Input Supply Relationship - these data reflect farm input usage in aggregate at alternative costs by input category.
2) Crop and Livestock Production Relationships - these data represent both the resource base available to U.S. agriculture and the state of technology in agriculture.
3) Marketing Relationships - for both domestic and export products these data reflect the relationship between farm value of products and retail value or export value.
4) Product Demand Relationships - these data represent the relationship between product prices and quantities demanded for both domestic and export products.
5) Right Hand Side Vector - constraint values. Exhibit A-5 represents a block diagram of the model in matrix form. Components of the matrix identify the tables that contain the data used. Thirty-six tables are required to capture the matrix values or coefficients in the AGSEM model. The remainder of this appendix relates these tables with matrix component explanation and source of the raw data.

Exhibit A-5

Activities	Input Supply	Crop Production	Production Flexibilities	Stock Mgmt.	Livestock Production	Domestic Marketing	Export Marketing	Domestic Demand	Export Demand	RHS
Bound	I(ii)	PPBND	FBND					D(dd)	E(ee)	
Net Social Benefits	I(ii)	CCOST	CJ		LCOST	MCOST	XCOST	D(dd)	E(ee)	
Land Restraints		CRL	CRL							LAND
Farm Input Balance	Steps (-1)	CINR(r)	CINR(r)		LIN					
Crop Supply & Utilization		CYL	CYL	STOCKS	LFEED	MDD	XEE			
Livestock Balance					LYL	MLT	XLT			
Domestic Product Balances						BDD (-1)		STEPD (1)		
Export Product Balances							BEE (-1)		STEPD (1)	

Input Supply Relationships

Three tables of data were used to describe the relationships of this category. Table ILA and IOI represent the additive segment formulation of the supply functions. These tables were constructed using a Fortran program that calculated costs and quantity steps along a constant elasticity function. Necessary input for the Fortran routine was the benchmark price, benchmark quantity, supply elasticity and number of steps desired. The mid-step or step #5 for nine steps represents the benchmark or existing costs for 1976-77. The base quantity is computed as the addition for the first five steps bounds. For table ILA, the benchmark price and quantity were $2.66 and 4471 hours with an elasticity of .3. For table IOI, the benchmark price is $1.00, the benchmark quantity 38,405.863 and supply elasticity is 3.0.

Table STEPS is shown as a component in Exhibit A-5. The data in this table are -1, reflecting that purchasing a unit adds one unit to the farm input balance. Table STEPS is not shown here.

Farm Input Supply (Labor)

ILA	COST	BND
S01	-1.56395570	4048.15893
S02	-2.09109130	222.891875
S03	-2.37903829	105.399060
S04	-2.54583758	72.1951384
S05	-2.66000000	44.7100000
S06	-2.77769863	72.1951384
S07	-2.96340332	105.399060
S08	-3.32928461	222.891875
S09	-4.20521928	471.358927

Farm Input Supply (Other operating inputs)

IOI	COST	BND
S01	-.855566330	28901.8867
S02	-.934096073	4800.23794
S03	-.968503388	2375.74912
S04	-.987235176	1751.90130
S05	-1.00000000	1152.17589
S06	-1.01244701	1751.90130
S07	-1.02962848	2375.74912
S08	-1.05820274	4800.23794
S09	-1.11164780	9698.95519

Table Elements: Cost elements represent the dollar per unit price of input, BND elements represent the maximum number of units that can be purchased at a specific unit price.

Source: Farm Income Statistics, Stat. Bulletin 576, July 1976. Changes in Farm Production and Efficiency, 1977, Stat. Bulletin 581, p. 32.

Crop and Livestock Production Relationships

Fourteen tables were constructed to represent the agriculture production category of the model. Input requirements were determined by the 1976 relationship between quantity of input used in production of a specific item and the harvested acreage or cash receipts of the production item. For instance, 1613 million hours of labor was used in 1976 in production of livestock and livestock products with total cash receipts from livestock amounting to $46,389 million. The labor requirement for livestock is 1613 ÷ 46389 = .0347712. This figure appears in table LIN. Input requirements for wheat, feed grains and other crops were based on a harvested acre basis, whereas fruits and vegetables and livestock production was based on a cash receipt concept.

Yield data was based on 1976 production divided by harvested acreage for wheat, feed grains and other crops. Production data was expressed in bushels, tons and dollars for wheat, feed grains and other crops, respectively. Fruits and vegetables and livestock yields were expressed as one dollar.

Objective function elements or costs for the agricultural production activities were defined as residual costs versus enterprise cost budgets. Objective function coefficients were defined as costs minus gross returns at equilibrium prices--thus assuring that agricultural production activities will be in equilibrium at their 1976 historical level. Crop activities were bounded at 1976 levels via table PPBND to insure stability of 1976 regional allocation and to allow production flexibility activities to be incorporated in the model.

Crop flexibility activities with a general identifier code of pprff were added to the model to reflect cost of increased production (through objective function increases) and sensitivity of farmers production patterns to price incentives (through quantity bounds). A supply elasticity of .4 was implied by the flexibility activities, i.e. a one percent increase in crop acreage was met by a 2½ percent increase in cost. Five flexibility steps or activities were included in the model for each of the 10 crop producing activities excluding

fruits and vegetables. Crop acreage was allowed to increase by steps of 1, 2.5, 5, 10, and 20 percent as costs increased by 2½ times the quantity increase. Production flexibilities added 50 more activities to the model. Tables FBND and CJ were created internally. Input requirements and yields for the production flexilibity activities were the same as regular crop production activities.

Land requirements in table CRL represent the land unit required per acre of production. The west-dryland region (R1) requires more than 1 acre of land for 1 acre of production due to summer fallow requirements.

Livestock production requires an additional input (feed grain) not required by crop production.

Table STOCK, not shown here, contains coefficients to allow for changes in beginning and year end grain inventories, as well as wheat feeding, etc.

Crop Production Costs

CCOST	WH	FG	OC	FV
R1	-26.701051	-13.425109	-4.470583	-.4535265
R2		-32.079919	-33.314077	
R3	-32.734289	-32.230207	-5.124081	
R4		-6.3608	-45.358281	

Table elements: Represent residual returns in dollars/acre by crop (WH, FG, OC, FV) for Regions (R1, R2, R3, R4).

Crop Yields

CYL	WH	FG	OC	FV
R1	-29.03353	-1.16997	-34.98173	-1.0
R2		-2.4801	-154.9728	
R3	-35.04114	-2.273393	-88.69864	
R4		-1.948246	-195.0323	

Table elements: Represent per acre yields by Crop and Region. Yields are expressed in bushels per acre for Wheat (WH), tons per acre for feed grains (FG) and dollars per acre for other crops (OC) and fruits and vegetables (FV).

Source: Crop Production, 2-1, 1978.

Crop Production Input Requirements

CINR1	WH	FG	OC	FV
LA	2.744625	2.599941	2.996719	.0653655
OI	21.96796	55.46015	8.72104	.3726035

CINR2	WH	FG	OC	FV
LA		5.511339	13.275787	
OI		117.93579	38.63513	

CINR3	WH	FG	OC	FV
LA	3.312541	5.05199	7.598398	
OI	26.513572	107.76581	22.11282	

CINR4	WH	FG	OC	FV
LA		4.32944	16.707496	
OI		92.3529	48.62208	

Table elements: Represent quantities of inputs required per acre of production by crops and regions.

Source: Crop Production
Farm Income Statistics

Cropland Requirements

CRL	WH	FG	OC	FV
R1	1.520169	1.071637	1.0	0
R2		1.0	1.0	
R3	1.0	1.0	1.0	
R4		1.0	1.0	

Table elements: Represent land acreage requirements per acre of production.

Crop Activity Bounds

PPBND	WH	FG	OC	FV
R1	55.655	26.425	35.703	100000.
R2	-	10.759	16.8493	-
R3	15.169	59.135	60.508	-
R4	-	10.452	36.065	-

Table elements: Represent acreage production limits in millions of acres by crop and region.

Source: Crop Production
June Enumerative Survey

LAND	RHS
R1	148.626
R2	27.608
R3	134.812
R4	46.517

Table elements: Represent the maximum amount of land available for each region in million acre units.

Source: Crop Production

Livestock Production Activity

LFEED	Feed Required LT
FG	.0027672

Table element: Expressed as million tons required per million dollars output.

LYL	Production LT
YIELD	-1.0

Table element: Expressed as millions of dollars.

LCOST	Cost LT
COST	-.2791617

Table element: Represent residual return per dollar output.

LIN	Input Requirements LT
LA	.0347712
OI	.3913749

Table elements: Labor expressed as million hours used per million dollars of output, other inputs is represented as million dollars input expense per million dollars of output.

Source: <u>Farm Income Statistics</u> <u>Changes in Farm Production and Efficiency</u>, 1977 Stat. Bull. 581.

Marketing Relationships

The marketing sector for this model contains eight data tables. Marketing cost data (table MCOST) represents the ratio of marketing bill per dollar of consumer expenditure for each product category. Similarly, export cost data (table XCOST) is interpreted as the ratio of export cost markup per dollar of export value. For instance, the marketing bill for livestock and livestock products in 1976 was $50,235 million and consumer expenditures amounted to $89,193 million resulting in cost coefficient of -.5632168 (table MCOST).

Marketing data in tables MDD, MLT, XEE, and XLT represent the farm value per dollar of consumer expenditure for domestic product or the farm value per dollar of export value for export products.

Tables BDD and BEE were internally generated with values of -1 to represent that one unit of marketing activity creates a unit for domestic or export demand.

Domestic Marketing Requirements

MDD	GB	MD	OF	NF
WH	.0238457	0	0	0
FG	.002723	0	.0000202	.0008333
OC	.0364479	0	.0376987	.4979427
FV	.0048303	0	.1948758	0

MLT	GB	MD	OF	NF
LT	0	.4367832	.0025511	.4306989

Table elements: Expressed as quantity or farm value in millions of dollars per million dollar of consumer expenditure.

Domestic Marketing Costs

MCOST	GB	MD	OF	NF
COST	-.8610203	-.5632168	-.7631439	0

Table elements: Represented as million dollar of marketing bill per million dollar of consumer expenditure.

Source: Ag. Statistics

1967 Input-Output Structure of U.S. Economy
arm Income Statistics

Export Marketing Requirements

XEE	WE	CG	OE	PE
WH	1.0			
FG		1.0		
OC			.864693	.1649167
FV				.0507058
(1976)				

XLT	WE	CG	OP	PP
LT				.1839853

Table elements: Represent millions of dollars of farm value per millions of dollars of export value.

Export Marketing Costs

XCOST	WE	CG	OE	PE
COST	-.885534	-20.40270	-.135307	-.6003922

Table elements: Represent the export cost markup per dollar export value.

Source: Agriculture Outlook
FATUS
Farm Income Statistics

Product Demand Relationships

Demand relationships in this model required ten tables of data. Four tables (DGB, DMD, DOF, DNF) represent the additive segment formulation of domestic product demand functions and tables EPE, EWE, EGG, EOE are similar representations of the export product demands. The construction of these tables paralleled that of the farm input supply functions. Benchmark price and quantity, demand elasticity and number of additive segments (steps) were input into a Fortran routine that created these tables. Constant elasticity demand functions were approximated by these additive demand segments. Twelve steps were specified for each product demand with the mid-step (step 06) representing the 1976 level.

The benchmark price and quantity with the demand elasticities for the eight products are:

Product	1976 LEVEL		Elasticity
	Price	Quantity (millions)	
Domestic			
Grain Mill & Bakery	$1.00	$23,543	-.15
Livestock Products	$1.00	$89,193	-.50
Other food	$1.00	$59,160	-.25
Non Food	$1.00	$13,903	-.32
Export			
Wheat	$4.004988/bu.	1020.4 bu.	-5.00
Coarse grains	$106.03871/ton	56.8 ton	-6.00
Other raw farm products	$1.00	$5869.863	-4.20
Processed ag products	$1.00	$7015.655	-1.00

Export elasticities shown here are the basic excess demand elasticities.

Two more tables in this category are BDD and BEE which were created internally to the model with coefficients of 1. These values represent that for a unit of product generated by marketing activity the demand activities utilize a unit of the activity.

Domestic Demand

DGB	Cost	BND
S01	1.69701186	22306.2731
S02	1.31335009	587.067374
S03	1.15234384	308.389756
S04	1.07692646	161.998854
S05	1.03959191	85.0988987
S06	1.01343615	94.1720000
S07	.986768302	94.1720000
S08	.962132213	85.0988987
S09	.929325440	161.998854
S10	.870363192	308.389756
S11	.769609122	587.067374
S12	.612638761	1117.57312

DMD	Cost	BND
S01	1.27009964	82471.7194
S02	1.12360773	3344.66189
S03	1.05939771	1680.28216
S04	1.02919749	844.135593
S05	1.01451061	424.074549
S06	1.00481734	428.126400
S07	.995217226	428.126400
S08	.985798503	424.074549
S09	.972027576	844.135593
S10	.945461183	1680.28216
S11	.895721543	3344.66189
S12	.807719870	6657.66941

DOF	Cost	BND
S01	1.61315308	55117.9935
S02	1.26249432	2235.32447
S03	1.12232351	1122.97624
S04	1.05924748	564.157756
S05	1.02923177	283.420042
S06	1.00965788	286.128000
S07	.990457326	286.128000
S08	.971798688	283.420042
S09	.944837608	564.157756
S10	.893896848	1122.97624
S11	.802317082	2235.32447
S12	.652411388	4449.49349

DNF	Cost	BND
S01	1.67730619	12442.6339
S02	1.29821813	693.386021
S03	1.14382756	364.239532
S04	1.07236844	191.337052
S05	1.03718271	100.510417
S06	1.01260384	111.226669
S07	.987602426	111.226669
S08	.964556845	100.510417
S09	.933941355	191.337052
S10	.879115463	364.239532
S11	.785947445	693.386021
S12	.641706000	1319.96703

Table elements: Cost-represents the per unit price for the domestic good, BND-represents the maximum amount of good that can be purchased at a given price.

Export Marketing

EPE	Cost	BND
S01	3.76731041	3724.49002
S02	1.52577216	1747.22262
S03	1.19282644	819.652321
S04	1.08205808	384.513066
S05	1.03688791	180.381723
S06	1.01697238	84.6201831
S07	1.00789094	39.6967900
S08	1.00250627	35.0782750
S09	.997506235	35.0782750
S10	.992231663	39.6967900
S11	.983584829	84.6201831
S12	.965646549	180.381723

EWE	Cost	BND
S01	8.00	40.
S02	7.32	22.
S03	6.75	33.6249
S04	6.12	59.3751
S05	5.55	78.0
S06	5.15	100.
S07	4.83	117.
S08	4.56	140.
S09	4.35	140.
S10	4.20	140.
S11	4.06	150.4
S12	3.94	160.

ECG	Cost	BND
S01	200.	2.
S02	178.	1.4
S03	163.	2.3468
S04	148.	4.2532
S05	134.	8.
S06	124.	9.7
S07	117.	9.7
S08	111.	9.7
S09	107.	9.7
S10	104.5	9.7
S11	102.	9.7
S12	99.5	9.7

EOE	Cost	BND
S01	2.2	266.
S02	2.	142.
S03	1.8	227.
S04	1.62	375.
S05	1.44	690.
S06	1.28	700.
S07	1.19	800.
S08	1.12	900.
S09	1.06	900.
S10	1.02	869.863
S11	0.98	930.137
S12	0.95	900.

Table Elements: Cost-represents the per unit price for the export good, BND represents the maximum amount that can be purchased at a given price.

Appendix B: Sample AGSEM Results

This appendix presents sample AGSEM model output by the Report Writer portion of the model. These results are abbreviated version of the standard Report Writer output. The solutions shown are:

Model A - The 1976 crop year baseline conditions.

Model B - The direct government purchase program to achieve 100 percent parity for all agricultural production with elastic export demands.

Model D - A restrictive marketing quota or production allotment program to achieve 100 percent parity for all agricultural production with elastic export demands.

Exhibit 1: SAMPLE AGSEM REPORT WRITER

		Model A	Model B	Model D
Wheat				
Acreage Harvested	Mil Ac	70.82	93.95	38.88
Yield	Bu/Ac	30.32	30.37	30.32
Production	Mil Bu	2147.39	2854.08	1178.92
Imports, Seed-Stock Chg	Mil Bu	486.70	486.70	486.70
Food Use	Mil Bu	561.39	553.26	553.26
Feed Use	Mil Bu	78.90	43.00	43.00
Exports	Mil Bu	1020.40	95.62	95.62
Sea. Ave. Price Received	Dol/Ac	3.14	5.90	5.90
Feed Grains				
Acreage Harvested	Mil Ac	106.77	145.78	75.91
Yield	Tn/Ac	1.98	1.98	1.98
Production	Mil Tn	212.40	290.10	151.01
Imports and Stk Chg.	Mil Tn	10.40	10.40	10.40
Food Use	Mil Tn	19.20	17.86	17.86
Feed Use	Mil Tn	126.00	137.73	116.83
Exports	Mil Tn	56.80	5.74	5.74
Sea. Ave. Price Received	Dol/Ac	86.33	134.93	134.93
Other Farm Production Quan.				
Other Field Crops (17)	1976=100	100.00	72.00	76.09
Fruits and Vegetables	1976=100	100.00	106.38	97.85
Livestock Products	1976=100	100.00	108.30	92.02
Other Farm Prices				
Other Field Crops (17)	1976=100	101.27	147.66	122.25
Fruits and Vegetables	1976=100	100.00	131.92	131.92
Livestock Products	1976=100	100.19	153.28	153.28
Farm Labor				
Hours	Mil Hr	4471.01	4504.78	3764.50
Wage Rate	Dol/Hr	2.66	2.77	1.56
Current Farm Oper. Exp (CY)				
Hired Labor	Mil Dol	6996.69	8713.57	3226.59
Feed Purchased	Mil Dol	11082.22	18759.38	15939.73
All Other Expenses	Mil Dol	38409.96	45808.23	30126.76
Total	Mil Dol	56488.88	73281.19	49293.08
Cash Receipts from Farm Mktg. (CY)				
Wheat	Mil Dol	6214.60	15481.14	6394.71
Feed Grains	Mil Dol	13584.58	29000.29	15096.51
Other Field Crops (17)	Mil Dol	16468.59	17289.80	15127.93
Fruits and Vegetables	Mil Dol	12086.02	16961.19	15602.29
Livestock and Products	Mil Dol	46478.33	77006.78	65432.16
Total	Mil Dol	94832.14	155739.22	117653.63

SAMPLE AGSEM REPORT WRITER (Con't)

		Model A	Model B	Model D
Realized Net Farm Income	Mil Dol	20389.25	64504.02	50406.54
Retail Prices				
Grain Mill+Bakery Prod	1976=100	100.13	109.86	108.93
Livestock Products	1976=100	100.08	123.27	123.27
Other Foods	1976=100	100.05	108.25	107.29
All Farm Foods	1976=100	100.07	116.48	116.07
Consumer Expenditures				
Grain Mill+ Bakery Prod	Mil Dol	23574.57	25490.78	25275.82
Livestock Products	Mil Dol	89268.02	101664.38	101664.38
Other Foods	Mil Dol	59639.80	63302.41	62742.06
All Farm Foods	Mil Dol	172482.39	190457.57	189682.27
Marketing Bill for Food	Mil Dol	115997.00	111052.44	111052.44
Farm Value-Dom. Food Prod.	Mil Dol	56485.39	79405.12	78629.82
Farm Value Dom-Non-Food Prod	Mil Dol	14011.33	18762.54	17187.68
Agricultural Exports				
Wheat	Mil Dol	4115.93	614.91	614.91
Feed Grains	Mil Dol	6062.52	892.71	892.71
Other Products (Raw)	Mil Dol	5934.65	2400.71	2861.74
Final Product-Processed	Mil Dol	7032.91	7180.07	7240.77
Total	Mil Dol	23146.02	11088.41	11610.14