# FEED DEMAND IN THE WORLD GOL MODEL

By Donald W. Regier*

▲ Agricultural commodity projections for 1985, developed by USDA's Economics, Statistics, and Cooperatives Service, show that the livestock sector acts as a large secondary grain reserve. A mathematical model of the combined world grain-oilseed-livestock (GOL) economy generates consistent projections of world commodity trade and prices, and regional production and consumption. The article presents analysis of the tie between crop and livestock sectors, located mainly in the developed countries. The focus is on the synthesis of feed demand equations containing input-output coefficients and price elasticities sensitive to both livestock products and feeds.

▲ World projections; agricultural commodities; livestock products; livestock feed; grain; oilseeds; mathematical model.

## INTRODUCTION

Agricultural commodity projections for 1985 developed by USDA's Economics, Statistics, and Cooperatives Service (ESCS), imply that the world livestock sector acts as a large, secondary grain reserve. Located mainly in the developed countries, the sector appears to act as a governor, or stabilizer, for adjusting regional rates of world production and consumption and prices of grain by regulating livestock production and feeding. The World GOL Model (combined grain-oilseed-livestock sectors), developed by ESCS and in use since 1974, generates consistent longrange projections of international commodity trade, world prices, and regional world production and consumption.

In this article, I analyze the tie between crop and livestock sectors in the model, focus on the role of feed demand, and consider the linkages between the feed and livestock sectors. I conclude with some broad implications of the design of the feed equations and their role in the model.

## THE WORLD GOL MODEL

The World GOL Model projects by region the crop areas, quantity of supply and distribution, net trade, and prices for each of 14 commodities basic in the feed-livestock complex: wheat, coarse grain (including corn), rice, oilmeal, soybeans, beef and veal, pork, poultry, mutton, milk, butter, and cheese.[1] The world is divided into 28 regions including a residual, and they are not symmetrically modeled. There are crop equations for all regions but not necessarily all crops. To date, there are livestock equations for only half the regions. There are reduced-form net trade equations for regions that contain the Centrally Planned countries. The U.S. sector is intended to be representative only; full U.S. models are used along with GOL in the ongoing ESCS projections program.[2] A total of 930 dependent variables is projected in a 930-equation system.

Within a region, the GOL model consists of eight major blocks of equations.

1—Demand: Livestock products
2—Supply: Livestock products
3—Demand: Crops for feed
4—Demand: Crops for food
5—Supply: Crops
6—Price linkages
7—Regional equilibrium
8—World equilibrium

The concern here is the structure of block 3, the demand for crops for feed. Feed demand is considered under two basic circumstances: first, when blocks 1 and 2, demand and supply of livestock products, are present in the model; and second, when they are absent.

## ROLE OF FEED DEMAND

Postulating a quantified livestock production function and deriving both livestock supply and feed demand functions from it was seriously considered in the planning

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[1] The World GOL Model was developed in ESCS primarily by Anthony S. Rojko, Program Leader; Donald W. Regier, livestock and derived feed; Patrick M. O'Brien, grains; Arthur L. Coffing, oilseeds; Robert D. Barry, rice; Myles J. Mielke, dairy; and Linda M. Bailey, statistical and computer effort. People who have contributed to the development of the computer programs include Francis S. Urban and Roger P. Strickland, Hilarius Fuchs during the main development stage, followed by Fenton Sands and Martin W. Schwartz.

[2] First use of the model in projections appears in (*4*), followed by (*21*). The model's broad characteristics are discussed in (*24*), and it is presented comprehensively in (*25, 26, 27,* and *18*). The projection focus shifts from 1985 to 2000 in (*23*). Note: Italicized numbers in parentheses refer to items in References at the end of this article.

For treatment of U.S. models whose domestic detail integrates with GOL world trade projections, see (*12, 15, 16, 29*).

stages for the GOL model. Arguments in favor of this approach are simplicity and mathematical elegance. The logic from production theory is straightforward and internal consistency of the resulting model is assured.

Because of difficulties in implementing such an approach, however, planners decided to use various sets of internationally comparable information that reveal important aspects of production processes used. A function responsive to price and technological development was postulated by region, for production of each important livestock commodity (block 2). Also, composite regionwide functions for feed grain and oilmeal demand were adopted, each with physical and price aspects (block 3). (See table 1 for the feed demand functions.)

Table 1- Equation forms for livestock feed demand, World GOL Model

| Block 3 | | |
|---|---|---|
| • Feed grain demand | = | F(production, beef, pork, poultry, milk; prices of beef, pork, corn, oilmeal) |
| | + | G(per capital income, population, changing tastes, productivity growth, policy factors) |
| • Feed wheat demand | = | F(feed grain demand; prices of wheat, corn) |
| | + | G(productivity growth, policy factors) |
| • Feed corn demand | = | Feed grain demand |
| | - | Feed wheat demand |
| • Feed oilmeal demand | = | F(production: beef, pork, poultry, milk; prices of beef, pork, corn, oilmeal) |
| | + | G(per capita income, population, changing tastes, productivity growth, policy factors) |

Note: F( ) indicates linear functions of endogenous variables.
G( ) indicates unrestricted functions of exogenous variables.

## LINKING CROP AND LIVESTOCK SECTORS

The link between crop and livestock sectors of the World GOL Model is importantly physical. The quantity of a commodity demanded as feed is a weighted sum of the livestock commodities produced in a region; the weights are the amounts of feed used in producing each livestock product. The final sum is adjusted, as shown below, by price considerations. Calculations of grain used as feed are made, first, in total, and, second, apportioned into feed demand for wheat and for coarse grain. Oilmeal is analyzed similarly. Use of rice as feed is ignored at this stage because of data problems. The equation pattern for feed demand (block 3) is shown in table 1, where F is a matrix of linear functions of endogenous variables and G is a set of exogenous, independently projected factors.

Like demand functions generally, demand for feed is related to a set of direct- and cross-price elasticities. It is also related to physical production of endogenous livestock products by a set of input-output coefficients expressing tons of grain or meal used to produce a ton of livestock product. Price terms and input-output rates are F-functions. G-functions include factors such as technological change or policy considerations which affect use of grain or meal as livestock feed. They also include per capita income and population to account for demand in those parts of the livestock sector which are not yet modeled in the interactive part of GOL.

## THE FEED-LIVESTOCK BALANCE

In the base from which projections are made—1970 or a span of years centered on 1970—the quantities of livestock commodities produced are balanced with the quantities of feed imputed to the use of each kind of animal product. Balancing (budgeting) is done in the light of limited information on feed conversion rates for different livestock products, different farming systems, and different practices in each of the 28 regions. Balances such as those shown in table 2 explicitly identify use rates (input-output ratios) for both grain and oilmeal, expressing tons of grain (or meal) used in producing a ton of livestock product. Such balances for each region are used for obtaining input-output ratios incorporated into the feed demand equations. The ratios are adjusted to account for the grain or meal reported as livestock feed in each region. Their regional variation constitutes a major asymmetry of the World GOL Model.

## CONSTRUCTION OF INPUT-OUTPUT COEFFICIENTS

Input-output rates in the model are not in terms of feed used per unit of time but of the quantity used per unit of product. Feeds were budgeted in the base 1970 period, to account for the livestock products of the region in terms of the entirety of grains and oilmeals. Discrepancies encountered led either to (1) a second round of coefficient estimation or (2) a projection procedure respecting the coefficients and treating the discrepancy term explicitly in the projections (table 2). The input-output rates were studied in a time perspective and allowance for change was made in the projected rates.

The observed input-output coefficients for conversion of feed into livestock commodities are behavioral relationships depending on (1) biological considerations, (2) local climate and plant ecologies, (3) local production systems, and (4) the affluence of the agriculturist

Table 2—Livestock production and use of grain and meal as feed, European Economic Community, 1970

| Livestock production | | Grain use as feed | | Oilmeal use as feed | |
|---|---|---|---|---|---|
| Product | Amount[1] | Use rate[2] | Amount[3] | Use rate[2] | Amount[3] |
| | *Mil. mt* | *Rate* | *Mil. mt* | *Rate* | *Mil. mt.* |
| *EC-6:* | | | | | |
| Meat | 13.000 | (2.278) | 29.616 | (.490) | 6.364 |
| Beef | 4.416 | 1.300 | 5.741 | .160 | .707 |
| Pork | 5.061 | 3.600 | 18.220 | .670 | 3.391 |
| Poultry | 1.920 | 2.700 | 5.184 | 1.180 | 2.266 |
| Mutton | .195 | .250 | .049 | | |
| Other | 1.408 | .300 | .422 | | |
| Other | | | | | |
| Milk | 71.448 | .130 | 9.288 | .034 | 2.429 |
| Eggs | 2.492 | 3.100 | 7.725 | .710 | 1.769 |
| Total | (13 000) | (3.587) | 46.629 | (.812) | 10.562 |
| *EC-3:* | | | | | |
| Meat | 4.500 | (2.844) | 12.797 | (.420) | 1.891 |
| Beef | 1.334 | 2.270 | 3.028 | .120 | .160 |
| Pork | 1.838 | 4.220 | 7.756 | .550 | 1.011 |
| Poultry | .686 | 2.700 | 1.852 | 1.050 | .720 |
| Mutton | .267 | .250 | .067 | | |
| Other | .375 | .250 | .094 | | |
| Other | | | | | |
| Milk | 20.778 | .210 | 4.363 | .025 | .519 |
| Eggs | 1.016 | 3.100 | 3.150 | .600 | .610 |
| Total | (4.500) | (4.513) | 20.310 | (.671) | 3.020 |
| *EC-9:* | | | | | |
| Meat | 17.500 | (2.424) | 42.413 | (.472) | 8.255 |
| Milk | 92.226 | (0.148) | 13.651 | (.032) | 2.948 |
| Eggs | 3.508 | (3.100) | 10.875 | (.678) | 2.379 |
| Grain: | | | | | |
| Estimated | | | [4]66.939 | | [4]13.582 |
| Actual | | | [5]66.911 | | [5]13.574 |

[1] Foreign Agricultural Service (FAS) supply and distribution figures supplemented by data from Food and Agriculture Organization (FAO) and the Organization for Economic Cooperation and Development (OECD). [2] Kg feed per kg livestock product. Use rates are obtained by budgeting with *a priori* knowledge from (*17, 19,* p. 6; *14,* pp. 118-119; *3; 31; 30; 8; 9; 11*). [3] Detail is the multiplication of livestock product detail by use rates. [4] Sum of above detail. [5] Reported by FAS.

Note: Italicized numbers in parentheses refer to items in References at the end of this article.

making decisions about how available crops will be shared by the family, the market, or animals in the form of feed. Although the practices of American agriculture are best known and documented, they stand at an extreme of behavior compared with world affluence (per capita income). Other developed countries typically use smaller quantities of grain in feeding livestock. Documentation by region, however, is difficult because of appreciable variation in local agricultural practice and infrequent or inadequate publication of data. Building the World GOL Model included obtaining and sometimes estimating this information.

As countries form a progression when classified by per capita income, so also they form a progression when classified by quantity consumed of meat per capita or proportion of grain allocated to livestock production (tables 3 and 4). Grain allocated to human food and to feed at the expense of food also tends to conform to the sequence. Thus one can judge the intensity of grain and oilmeal feeding, in regions with poor data, by looking at consumption and income. This consumption progression is referred to here as the Main Sequence. Variation observed in the feeding rates of the parts of the European Community and the United States is predictable from the Main Sequence (see figure 1 and table 3).

The United States, Canada, Japan, and parts of Western Europe possess grain-intensive beef industries, and in Europe, this industry is on the increase. Elsewhere, the grain-intensive meat industries are pork and poultry production. In much of the world, beef production is considered to be a byproduct of the dairy industry. Analysts cannot avoid arbitrary judgments in allocating feed to poultrymeat as against eggs, and to beef versus milk. And in important regions, allocation of feed must

Table 3—Per capita income and estimated meat and grain consumption, world, 1962

| Income per capita | Meat | Grain for food and feed | | | Income elasticity | | Grain-meat ratio[1] | Feed grain share[2] | Income per capita |
|---|---|---|---|---|---|---|---|---|---|
| | | Food | Feed | Both | Meat | Grain | | | |
| *Dollar equivalent* | *Kilograms* | | | | *Rate* | | | *Percent* | *Dollar equivalent* |
| 25 | 0 | 48.8 | 0 | 48.8 | ∞ | .84 | 0 | 0 | 25 |
| 50 | 0 | 117.8 | 0 | 117.8 | ∞ | .32 | 0 | 0 | 50 |
| 75 | 5.2 | 144.3 | 4.0 | 148.3 | 3.41 | .15 | .7 | 0 | 75 |
| 100 | 9.8 | 156.5 | 13.0 | 169.5 | 1.50 | .07 | 1.3 | 2 | 100 |
| 125 | 12.9 | 164.3 | 22.0 | 186.3 | 1.00 | .01 | 1.7 | 5 | 125 |
| 150 | 15.2 | 159.4 | 30.0 | 189.4 | .82 | -.02 | 1.9 | 8 | 150 |
| 200 | 18.7 | 154.9 | 44.0 | 198.9 | .65 | -.06 | 2.3 | 12 | 200 |
| 250 | 21.4 | 148.9 | 53.0 | 201.9 | .58 | -.09 | 2.5 | 15 | 250 |
| 300 | 23.8 | 142.8 | 63.0 | 205.8 | .56 | -.11 | 2.6 | 17 | 300 |
| 350 | 25.9 | 137.3 | 71.0 | 208.3 | .55 | -.12 | 2.7 | 19 | 350 |
| 400 | 27.9 | 132.1 | 79.0 | 211.1 | .56 | -.13 | 2.9 | 20 | 400 |
| 450 | 29.8 | 127.5 | 86.0 | 213.5 | .57 | -.14 | 2.9 | 22 | 450 |
| 500 | 31.6 | 123.3 | 102.0 | 225.3 | .63 | -.14 | 3.2 | 24 | 500 |
| 750 | 40.3 | 107.2 | 138.0 | 245.2 | .63 | -.16 | 3.4 | 30 | 750 |
| 1,000 | 48.6 | 96.2 | 173.0 | 269.2 | .68 | -.17 | 3.6 | 36 | 1,000 |
| 2,000 | 80.9 | 75.9 | 320.0 | 395.9 | .79 | -.18 | 4.0 | 57 | 2,000 |
| 3,000 | 112.8 | 61.4 | 484.0 | 545.4 | .85 | -.18 | 4.3 | 77 | 3,000 |

[1] Kg grain per kg meat. [2] Feed in total grain consumption. Note: ∞ = infinity. Italicized numbers in parentheses refer to items in References at the end of this article.

Sources: Main Sequence equations—(*18*, Ch. 2; *19*, pp. 81-118).

Table 4—Demand elasticities, world

| Commodity | Price elasticity | | Income elasticity |
|---|---|---|---|
| | Meat | Grain | |
| Meat | .60 | .60 | .60 |
| Grain | .43 | .43 | .14 |

Sources: Main Sequence equations evaluated at the means; (*18, 19*).

Note: Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

be made among beef, milk, and work. For oxen continue to be important as work animals, and sometimes milk cows are used for work.

OECD member country response to questionnaires on intensity of feed utilization (*14*) has helped scale the GOL input-output coefficients. Feed utilization rates tabulated for 1962, 1975, and 1985 are in basic harmony with the data underlying figure 1. They helped calibrate coefficients for the developed regions, Oceania, and (by inference) Argentina.

## PRICE-ELASTICITY MATRIX

Price adjustment terms enter the feed demand equations which are based on estimates of direct- and cross-price elasticities for livestock products and for feed inputs. Research in ESCS has shown that feed demand equations conform well to the data when estimated from price series which are ratios of product prices to feed input prices (table 5).

Such relations, however, are nonlinear in numerators and denominators. Since the World GOL Model requires linearity among endogenous variables, elasticities of equal absolute value were assigned to numerator and denominator, but with sign changed in the denominator. Positive elasticities on meat prices, say, imply that an increase in a meat price brings an increase in feed use. Negative price elasticities on feed price, correspondingly, imply that a rise in a feed price brings a drop in livestock feeding. World cross-section calculations suggest that price response in demand may be the same, or proportional, over the world (table 4).

Table 5—Demand for livestock feed, EC-6

| Feed use | Price ratios | | | | Production constant | | $R^2$ DW |
|---|---|---|---|---|---|---|---|
| | PMG | PMO | POG | PGO | XM | K | |
| Grain | | | | | | | |
| FG | .491 | | | | 1.123 | -62.945 | .97 |
| | (.266) | | | | (.095) | | 1.27 |
| | E .51 | | | | E 1.26 | | |
| FG | .521 | | -.128 | | .881 | -31.671 | .99 |
| | (.129) | | (.054) | | (.108) | | 2.13 |
| | E .55 | | E -.14 | | E .91 | | |
| Oilmeal | | | | | | | |
| FO | | 1.144 | | -1.430 | 3.134 | -180.377 | .98 |
| | | (.530) | | (.506) | (.417) | | 2.23 |
| | | E .97 | | E -1.15 | E 2.77 | | |

FG is feed consumption of grain, index of physical tonnage, 1960 = 100.
FO is feed consumption of oilmeal, index of physical tonnage, 1960 = 100.
PMG is the ratio of the price of meat to the price of grain, index 1960 = 100.
PMO is the ratio of the price of meat to the price of oilmeal, index 1960 = 100.
POG is the ratio of the price of oilmeal to the price of grain, index 1960 = 100.
PGO is the ratio of the price of grain to the price of oilmeal, index 1960=100.
XM is domestic production of meat and livestock, index of physical tonnage, 1960 = 100.
E is an elasticity evaluated at the means.
Standard errors are reported in parentheses.
Sources: (*18, 32*). Compare these results with those for the United States in (*1*).

## WORLD CONSUMPTION OF GRAIN AND MEAT

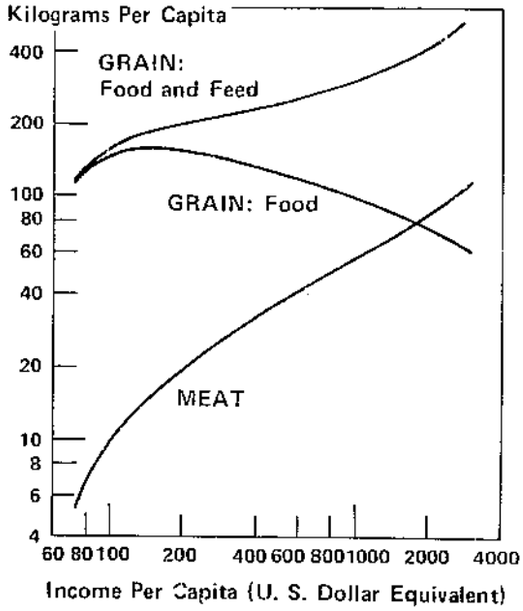


FIGURE 1

## FEED DEMAND EQUATIONS

The elements discussed above are incorporated into the feed demand equations in this section. The feed demand equations in the World GOL Model for the EC-6 appear in table 6. The input-output rates in the equations can be traced from the rates in table 2. These relate domestic production of livestock products to total grain fed. The price coefficients represent elasticities of +.50 for pork, −.50 for corn, and +.10 for oilseed cake. In each equation a growth term is applied to the entire quantity of feed grain budgeted for livestock in the 1970 base period. The EC-6 growth term is 5 per mil (5 tenths of 1 percent) per annum, representing the European trend toward more grain-intensive livestock feeding practices.

Table 6 also shows the demand for feed wheat in the EC-6 as a linear function of total demand for feed grain and of the prices of wheat and corn. The proportion of wheat in total feed grain tends to rise with higher corn prices or lower wheat prices. Corn demand is a residual calculated by subtracting feed wheat from total feed grain.

Coarse grain demand in Brazil is shown (table 7) because it illustrates the GOL method for estimating feed demand in regions with deficient livestock feeding data or with rudimentary livestock sectors. Two input-output terms are shown, and price coefficients implying elasticities of +.30 for pork, −.40 for corn, and +.10 for oilseed

cake. For demand for livestock products not represented by beef and pork (the explicit terms in the equation), an income elasticity of .20 is stipulated. This elasticity, together with income- and population-growth terms shown in the table, determines the overall growth of this component of livestock feed demand.

Demand for oilmeal is illustrated from the EC-3 (table 8). Input-output coefficients are traceable to table 2. Price elasticities incorporated into equation coefficients are +1.80 for pork, +1.00 for corn, and −.37 for the direct price of oilseed cake. In structure the feed grain and oilmeal equations are similar, but the meal elasticities are greater. The 5 per mil growth term is comparable with the projected EC-6 growth term in grain feeding.

The growth terms used in these feed equations represent judgments concerning the future based on knowledge of economic development plans and projects under way around the world and a record of accomplishment or failure in the past.

Table 6—Demand for feed grain, EC-6, World GOL Model

| | | | |
|---|---|---|---|
| Demand for feed grain | | | |
| • Total grain fed to livestock (1,000 mt) | = | | Domestic production (1,000 mt): |
| | | + | 1.3000 Beef and veal |
| | | + | 3.6000 Pork |
| | | + | 2.7000 Poultry |
| | | + | .2500 Mutton and lamb |
| | | + | .1248 Milk |
| | | + | 3.1000 Eggs |
| | | | Price (Units of Account/t): |
| | | + | 30.9200 Pork |
| | | − | 304.4099 Corn |
| | | + | 45.7200 Oilseed cake |
| | | | Growth term |
| | | + | 46625.0000 (1.0 + .005) Time |
| | | − | 46465.8000 Constant |
| • Wheat fed to livestock (1,000 mt) | = | | Total grain fed to livestock (1,000 mt) |
| | | + | .1850 |
| | | | Price (Units of Account/t): |
| | | − | 20.0000 Wheat: Demand price |
| | | − | 50.0000 Wheat: Trade price |
| | | + | 50.0000 Corn: Trade price |
| • Coarse grain fed to livestock (1,000 mt) | = | | Total grain fed to livestock (1,000 mt) |
| | | + | 1.0000 |
| | | | Wheat fed to livestock (1,000) mt) |
| | | − | 1.0000 |

Table 7—Demand for feed grain, Brazil, World GOL Model

| | | | |
|---|---|---|---|
| Demand for feed grain | | | |
| • Coarse grain fed to livestock (1,000 mt) | = | | Domestic production (1,000 mt): |
| | | + | 1.5000 Beef and veal |
| | | | 3.6000 Pork |
| | | | Price (Dollar equivalent/t): |
| | | + | 4.9440 Pork |
| | | − | 84.3100 Corn |
| | | + | 12.9900 Oilseed cake |
| | | | Growth term |
| | | + | 5928.0000 (1.0 + 8) Time where: |
| | | | 8 = a(b) + c = .04028 and |
| | | | a = .2000 income elasticity |
| | | | b = .0589 income growth rate |
| | | | c = .0285 population growth |
| | | + | .5000 Constant |

Table 8—Demand for oilseed meal, EC-3, World GOL Model

| | | | |
|---|---|---|---|
| Demand for oilseed meal | | | |
| • Oilseed meal fed to livestock (1,000 mt) | = | | Domestic production (1,000 mt): |
| | | + | .1200 Beef and veal |
| | | + | .5500 Pork |
| | | + | 1.0500 Poultry |
| | | + | .0250 Milk |
| | | + | .6000 Eggs |
| | | | Price (Units of Account/t): |
| | | + | 6.7300 Pork |
| | | + | 110.4500 Corn |
| | | | 10.5300 Oilseed cake |
| | | | Growth term |
| | | + | 3028.0000 (1.0 + .005) Time |
| | | − | 14273.0000 Constant |

## CONCLUSIONS

From one projection run on the computer to another, demand categories of grain for food and feed, oilmeal, and of meat production tend to move together. However, feed demand tends to respond with more sensitivity than food grain demand to variation in the assumptions underlying the alternative projections. In the various projections developed, quantities for meat production and consumption and grain for food have differed in a range of approximately 10 percent, whereas feed grain demand has varied through about 20 percent. The feed

grain variation occurs in the regions comprising the commercial meat economy of the world, thus, largely in the developed countries.

The variation among projections, in million metric tons, is shown in figure 2. Meat varied by 9 million tons, feed grain by 87 million, food grain by 53, and oilmeal by 9 million tons, with the meat, meal, and feed grain variation occurring largely in the developed countries. The 1985 projection levels (table 9)[3] ranged from 918 to 1,056 million tons for grain, 66 to 73 million tons for oilmeal, and 96 to 105 million tons for meat. The grain-to-meat conversion rate was 3.8 in the low projection and 4.3 in the high.

If the World GOL Model has been realistically designed, these results imply that the world livestock sector does act as a large secondary grain reserve. It is mainly a phenomenon of the developed countries and appears to help stabilize the world grain economy. Grain consumption as food appears strikingly stable in the developed countries while varying substantially in the less developed countries—but less than the variation in feed grain consumption. When world grain production is low, grain feeding apparently declines in the developed countries, mainly the United States and Europe. High world grain production tends to result in lowered feed prices which encourage larger developed country output of feed-intensive livestock products.

Additionally, the 1985 projections with the World GPL Model show that:

- High volume markets are for food grain in the developing countries and for feed grain in the developed countries;
- Developed country market for feed grain is large and growing;
- Developing country market for feed grain, though modest in scale, is growing faster than that in developed countries;
- Highest growth markets are for food and feed grain in the developing countries.

[3] For a more elaborate treatment of the projection results obtained with the World GOL Model, consult sources cited in footnote 2.

**WORLD GOL MODEL: PROJECTION VARIATION AMONG ALTERNATIVES FOR 1985**

**Figures in Million Metric Tons**

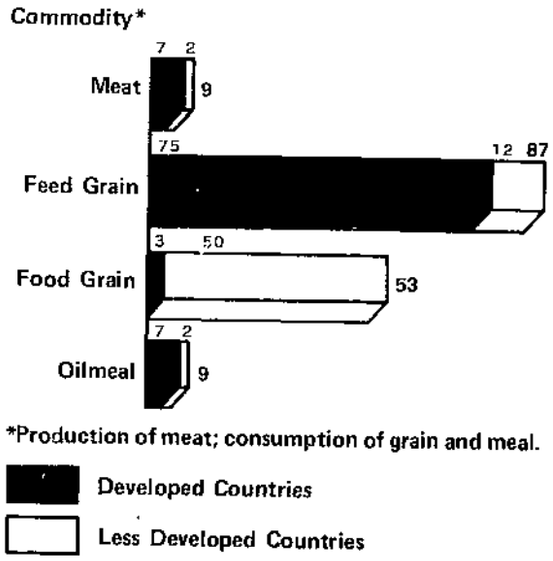


FIGURE 2

Table 9—Extremes of projections to 1985, World GOL Model

| Projection alternative | Grain consumption | | | Oilmeal consumption | Meat production | Input-output rates | |
|---|---|---|---|---|---|---|---|
| | Total | Food | Feed | | | Grain | Meal |
| | *Million tons* | | | | | *Rate* | |
| Low | 918 | 551 | 367 | 66 | 96 | 3.8 | .69 |
| DC | 453 | 134 | 319 | 55 | 63 | 5.1 | .87 |
| LD | 465 | 417 | 48 | 11 | 32 | 1.5 | .34 |
| High | 1,056 | 601 | 454 | 73 | 105 | 4.3 | .70 |
| DC | 529 | 135 | 394 | 62 | 70 | 5.6 | .89 |
| LD | 526 | 466 | 60 | 11 | 35 | 1.7 | .31 |

Notes: DC is Developed Countries; LD is Less Developed Countries; "Low" and "High" are world totals for tonnages or world averages for input-output rates. Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

Sources: Summarized from (*25*) and (*18*).

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*In Earlier Issues*

Sir Horace Plunkett was an Irish institution, with broad English and American exposures. He was Irish by birth and deepest loyalty; part English by ancestral background and political participation; part American by lifelong business interests here. A core activity of his revolved around the establishment and expansion of agricultural cooperatives. He ranks with Grudtvig of Denmark and Raiffeisen of Germany as a pioneer in this field. He was anxious that a correct relationship exist between private enterprise and the government; that voluntary and statutory action be kept in constructive balance; and that self-help and state-aid be truly complementary. He hit upon the slogan "Better farming, Better business, Better living." President Theodore Roosevelt became tremendously interested in his three "betters," and presently announced them to rural America.

Arthur F. Raper
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