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by

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IMPACTS OF CHANGING CONSUMER MEAT DEMAND ON THE FEED GRAIN INDUSTRY

Eugenia Bair

Introduction

The changing mix in the demand for meats has been well documented by several authors including Brachler (1983), Chavas (1983) and Mintert (1986). While debate exists among these authors on the cause and duration of these shifts, the impact of these changes on the feed grains and oilseed industries needs to be better quantified. This study attempts to help fill that void through the use of an econometric model of the U.S. feed grains and oilseed industries.

Per capita consumption of chickens has increased by 18 pounds since 1975. During the same period, consumption of beef has declined by 9 pounds. While the total consumption of meats on a per capita basis has not changed substantially, this shift in the mix of meats does have implications for the feed industry. The approximate feed-to-meat conversion rate for feedlot beef is reported at 7.5:1, for pork at 4:1. At the other end of the spectrum are chickens with a feed-to-meat ratio of 2:1 (Brown, 1983). Further examination indicates that 6 percent of the feed consumed by fed cattle was high protein meal. For pork, protein amounted to 17 percent of total feed and for broilers, protein was 41 percent of total feed (USDA, 1986). While these percentages vary with input and output prices, they indicate that the shift in meat consumption may not only lower the overall demand for feed inputs, but may further heighten the competition between corn and soybean meal.

This paper will investigate the issue of how changes in meat consumption patterns ultimately affect the demand for feed grains and protein supplements. Three meat demand paths representing alternative beef-pork-poultry market shares will be examined over a six year period through simulation analysis. The first, which might be termed the baseline scenario, continues consumption patterns over the 1986-1991 as were forecast in a recent analysis based on the macroeconomic conditions expected to prevail. The second simulation changes the market shares of the three meat products consistent with the trends observed over the period 1971-1976, a period during which beef consumption was large and poultry consumption was small but growing. The third scenario allows the market share of poultry to increase relative to beef and pork but at a faster rate than is observed under the baseline. The consumption patterns are translated into feed grain and protein demands for the crops sector. In particular, the corn and soybean meal industries are investigated.

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U.S. Crop Model

The Food and Agricultural Policy Research Institute (FAPRI) operates an annual econometric model of the U.S. agricultural sector. The major crops produced in the U.S. are an integral part of the total model. The crop models include corn, wheat, soybeans, soybean meal, soybean oil, rice, oats, sorghum and cotton. Each of the commodity models includes behavioral relationships for production, stocks, utilization and prices. Each of the models can be operated by itself to determine the market price and related quantities or simultaneously with other commodity components. The commodity models considered in this analysis include corn and soybean meal. The structural design of the corn model in Figure 1 illustrates the flow of information signals through the market system and indicate the types of information used or generated in these models. The soybean-meal-oil model is similar.

The commodities are linked together for policy analysis and forecasting purposes. These links between commodity markets reflect the interaction between price and quantity movements across market structures. For example, livestock prices and herd size condition the demand for feed grains while feed grain prices, in turn, influence investment and production decisions for livestock. Accurately reflecting these links across commodities is particularly important for policy evaluation and forecasting. However, in this analysis, we exogenize all commodity models except corn and meal models. These two commodities are linked together for analysis purposes in this paper. The FAPRI corn model consists of ten behavioral equations and four identities estimated over the period 1961 to 1984. The meal model consists of two behavioral equations and two identities fit over the same period. Since we are discussing the impacts of changing consumer meat demand on the feed grain industry, we introduce the feed demand for corn and meal equations as follows:

```
CORDF = -2989.6 - 366.47 * CORPF + 0.3767 * SOMPM44D
        + 61.914 * GCAU + 928.59 * LIVIF(+1)
        + 491.92 * DUM82.
SOMDD = -7696.8 - 27.696 * SOMPM44D + 1024.926 * CORPF
        + 162.74 * HPAU + 5171.259 * LIVIF(+1) - 1.174
        * FEEDHPS - 2487.32 * DUM74.
CORDF = Corn Feed Demand, Million Bushels
CORPF = Corn Price $/Bushel
SOMPM44D = Meal Price, 44% Protein , $/Ton
GCAU = Grain Consuming Animal Units
LIVIF = Livestock Price Index, 1953-1957 = 1.0
SOMDD = Meal, Domestic Use, Thousand Tons
HPAU = High Protein Animal Units
FEEDHPS = Feed, High Protein Less Soymeal, Thousand Tons
DUM__ = Dummy Variable for Year 19__
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Livestock Assumptions

For comparison, consumption levels of beef, pork and chicken are shown in Table 1. These alternative consumption levels were used to generate animal inventories (e.g., breeding herd and marketing groups) and subsequent feed grain demand paths. The baseline scenario reflects a portion of the current (Spring 1986) 10 year forecast generated by FAPRI and Wharton Econometric Forecasting Associates. It recognizes a generally declining demand for red meats and an increasing market share obtained by chicken. The second scenario is based on the consumption paths of beef, pork and chicken over the period 1970 to 1975. During that period, beef consumption was considerably higher than currently (although partially as a result of beef herd liquidation in 1974 and 1975 (reflected as 1990 and 1991 in the scenario)). Poultry consumption was quite low but rising. The third scenario reflects a short reduction in the consumption of red meats and a rise in chicken consumption. While these scenarios certainly do not exhaust the range of possibilities, they do represent an interesting set of animal numbers which impact feed grain and protein demand.

From the animal numbers generated endogenously by the livestock models, grain consuming animal units (GCAU) and high protein animal units (HPAU) are obtained. These technical equations are based on previously specified U.S. Department of Agriculture relationships and attempt to recognize the contribution or importance of cattle, pork, or poultry in determining feed grain and protein demand. As indicated below, cattle numbers play a relatively more important role in GCAUs whereas pork and poultry increase in relative importance when determining HPAUs.

```
GCAU    = (COWSNMC + COWSEMC / 0.6) * 1.1168
        + SAHKSFD * 0.78141 + (COWSNBE + HEISBBE) * 0.21805
        + (0.5 * CHISPYO + CHIAPOT) / 0.00886
        + (HOGSNBR(-1) + HOGSM(-1) + PIGSC) * .1958
HPAU    = 0.5708 * (HOGSM + 0.5 * PIGSC)
        + 0.0075 * (CHISPYO / 2.9 + CHIAPOT / 2.7)
        + 0.0716 * CHISVLA + 0.00486 * TURAP
        + (COWSNMC + COWSEMC * 0.6 - COWKSMC * 0.6) / .725
        + .1508 * (2 * SAHKSFD + COWSNBE + HEISBBE)
GCAU    = Grain Consuming Animal Units
HPAU    = High Protein Animal Units
COWSNMC = Dairy Cows on Farms, January 1, Million Head
COWSEMC = Dairy Cow, Additions to Herd, Million Head
SAHKSFD = Steer and Heifer Feed Slaughter, Million Head
COWSNBE = Beef Cows on Farms, January 1, Million Head
HEISBBE = Heifers, Beef Number for Breeding, Million Head
CHISVLA = Chickens, Layers, Number on Farm, January 1,
          Million Head
CHISPYO = Chickens, Young, Production, Million Pounds
CHIAPOT = Chickens, Other, Production, R.T.C., Million Lbs.
HOGSNBR = Hogs, Breeding, Number on Farms, December 1,
          Million Head
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HOGSM = Hogs, Market, Number on Farms, December 1, Million Head
PIGSC = Pig Crop, Million Head
TURAP = Turkey Production, Million Lbs.
COWKSMC = Dairy Cow Slaughter, Million Head

Results

Solving the FAPRI crop model over the evaluation period involves a sequence of steps including (1) identifying the general economic assumptions for the U.S., (2) developing foreign sector projections, (3) specifying farm policy parameters, (4) aligning annual solutions to the model, and (5) iterating forward sequentially from the base year. For a detailed discussion of this process, the interested reader is referred to Womack et al., (1985). The assumptions with respect to domestic macroeconomic activities and foreign projections come from the FAPRI and Wharton (1986) ten year forecast of Spring, 1986.

Scenario I: Baseline

Table 2 reports the results from the FAPRI crop model solved over the period 1986 to 1991. In this baseline analysis, we assume that the per capita beef consumption decreases steadily from 79.8 pounds to 64.8 pounds in 1989 before rising to 66.1 pounds in 1991, decreasing the beef consumption share from 41 to 34 percent over the next six years. Per capita pork consumption cycles from 59.6 pounds to 68.7 pounds in 1990 before declining to 63.0 pounds in 1991, increasing the pork consumption share from 30 percent in 1986 to 33 percent in 1991. Per capita chicken consumption increases continuously from 56.8 to 64.7 pounds. Consequently, the chicken consumption share increases from 29 to 33 percent. These baseline per capita consumption patterns reflect increasing GCAU and HPAU. The numbers in Table 1 show that GCAU increases from 91.21 to 97.05 in the next six years and HPAU increases from 159.57 to 171.52 by 1991. The rising GCAU path increases feed demand for corn from 4081 million bushels to 4374 million bushels and raises corn price from $1.50 to $1.82 per bushel. Consequently, the ending stocks decrease from 5688 bushels to 5257 million bushels. The increasing HPAU results in increasing feed demand for soybean meal from 20133 to 22041 thousand tons. Therefore, meal price rises from $148 to $161 per ton.

Note that for both GCAU and HPAU series, peak levels are reached in 1989/90. Similarly, corn price and soybean meal price are highest for those same years. This year reflects the peak of pork production and rising beef and poultry production. In the two subsequent years, although beef and poultry production increase, pork production drops sharply, reducing with it both GCAUs and HPAUs.

Scenario II: High Beef

The scenario which we call high beef for the livestock sector increases the share of beef consumption consistent with the trends observed in the period 1971-1976. Therefore, we assume that per capita beef consumption increases from 84.0 pounds to 87.9 pounds over the six year period, relatively higher than baseline beef consumption in each year. This scenario reflects an increase in the beef consumption share from 46 to 50 percent. Per capita pork consumption decreases from 62.3 pounds to 50.7 pounds, causing a decline in pork consumption share from 34 to 29 percent. Per capita chicken consumption increases from 36.3 pounds to 36.8 pounds, resulting in a slight rise in the chicken consumption share from 20 to 21 percent.

Over this scenario, GCAUs decline from 100.36 to 93.01. This result may seem counter intuitive, at least at first glance. One might expect that a higher beef consumption share should lead to increased GCAU. However, two factors combine to account for this situation. First, note that in Table 1, total meat consumption is lower relative to that of the baseline. Second, the pattern in 1990 and 1991 follows that of 1975 and 1976. Feed utilization fell by 1 billion bushels between 1974 and 1975 due to a combination of depressed livestock prices and high corn prices in 1974. The higher per capita total meat consumption in 1975 (i.e., 1990) was due to increased non-fed steer and heifer slaughter and beef cow liquidation and results in decreasing GCAU. With decreased demand for corn for feed (reflected by declining GCAUs), corn production and prices drop relative to the baseline (Table 3). However, stocks accumulate, and by the end of the period, are higher than at the beginning (and relative to the baseline).

The high beef scenario results in an HPAU lower than the baseline, decreasing from 143.55 to 136.83. This translates into a feed demand for meal lower than the baseline, decreasing from 16755 thousand tons to 12985 thousand tons (Table 3). The significantly lower demand for meal leads to decreased prices.

This scenario is somewhat peculiar in that while it reflects a higher market share of meat consumption by beef, it also shows the ramifications of dramatic feed cost shocks on the livestock sector. The meat consumption patterns were disrupted in 1975 and 1976 (reflected as 1990 and 1991) due to weather-related crop price increases in 1974. Sharp liquidation by both beef (for two years) and pork (for one year) producers increased meat supplies but did not raise GCAUs and HPAUs. In fact, these declined dramatically in 1990 (Tables 1 and 3). This explains the irregular pattern of pork consumption over this scenario and reflects the importance of feed costs in animal production enterprises.

Scenario III: High Poultry

The high poultry scenario increases the meat consumption share of chicken. Table 1 reports the per capita meat consumption assumptions. Per capita beef consumption decreases from

79.8 pounds to 61.5 pounds. Hence, the beef consumption share decreases from 41 to 35 percent. While this is a larger absolute (in pounds) decrease than the baseline, market share does not drop as sharply. Per capita consumption of pork decreases from 59.6 pounds to 47.3 pounds, with the pork consumption share declining from 30 to 27 percent. As per capita consumption of chicken increases from 56.8 pounds to 65.8 pounds, the chicken consumption share rises from 29 to 38 percent. These assumptions result in a decline in GCAU from 89.27 to 79.76, a lower level of grain consuming animal units than in the baseline. The lower GCAU results in a feed demand for corn that is lower than in the base line. Corn feed demand decreases from 3963 million bushels to 3304 million bushels over the next six years (Table 4). The decline of corn feed demand results in dropping the corn price from $1.48/bushel to $1.29/bushel. Since we assume total production of corn is fixed, the decreased corn price leads to increased corn ending stocks from 5802 billion bushels to 9065 million bushels.

HPAUs increase slightly over the period from 155.55 in 1986 to 157.57 in 1991. However, this is lower than the baseline due in large part because of substantially lower hog numbers. The slightly increased HPAU combined with the decreased price of substitute goods results in decreasing feed demand for meal from 19098 to 16697 thousand tons over the period, a lower demand than the base line (Table 4).

Conclusion

A large econometric model of the U.S. crop sector which includes corn and soybean meal was employed to assess the effects of alternative consumer meat demand on the U.S. feed grains industry over the period 1986 to 1991. Three scenarios were examined. The first, a baseline, assumed that meat consumption patterns of beef, pork and chicken would continue through 1991. Under this scenario, both GCAUs and HPAUs increase as the livestock industry responds with increasing production to the relatively low crop prices.

Scenarios two and three were compared with the baseline under varying consumption path alternatives. A relatively high beef (and low poultry) market share in scenario two generated larger GCAUs and lower HPAUs at the beginning of the analysis period. However, by the end of the period, sharp liquidation of beef and pork reduced both GCAUs and HPAUs. As a result, feed demand and crop prices fell.

In scenario three, chicken market share was allowed to increase at a rate faster than under the baseline. Pork and beef consumption fell. As a result, GCAUs were sharply lower than the baseline. HPAUs were also below the baseline as pork production declines reduced HPAUs more than chicken production increases raised them. Because of the large drop in GCAUs, corn stocks increased to record levels and prices fell over the analysis period.

While scenarios two and three reflect artificial situations, they do indicate the importance of changing domestic livestock production and consumption on feed grain and protein demand. Scenario two indicates that weather can play a major role in costs to the livestock sector and impact the crops sector over a relatively long time period. Scenario three indicates that if consumers step up their rate of substitution of chicken for beef and pork, the corn industry will be hard hit. Anticipating these changes and their impacts can provide lead time for prescriptive farm policies.

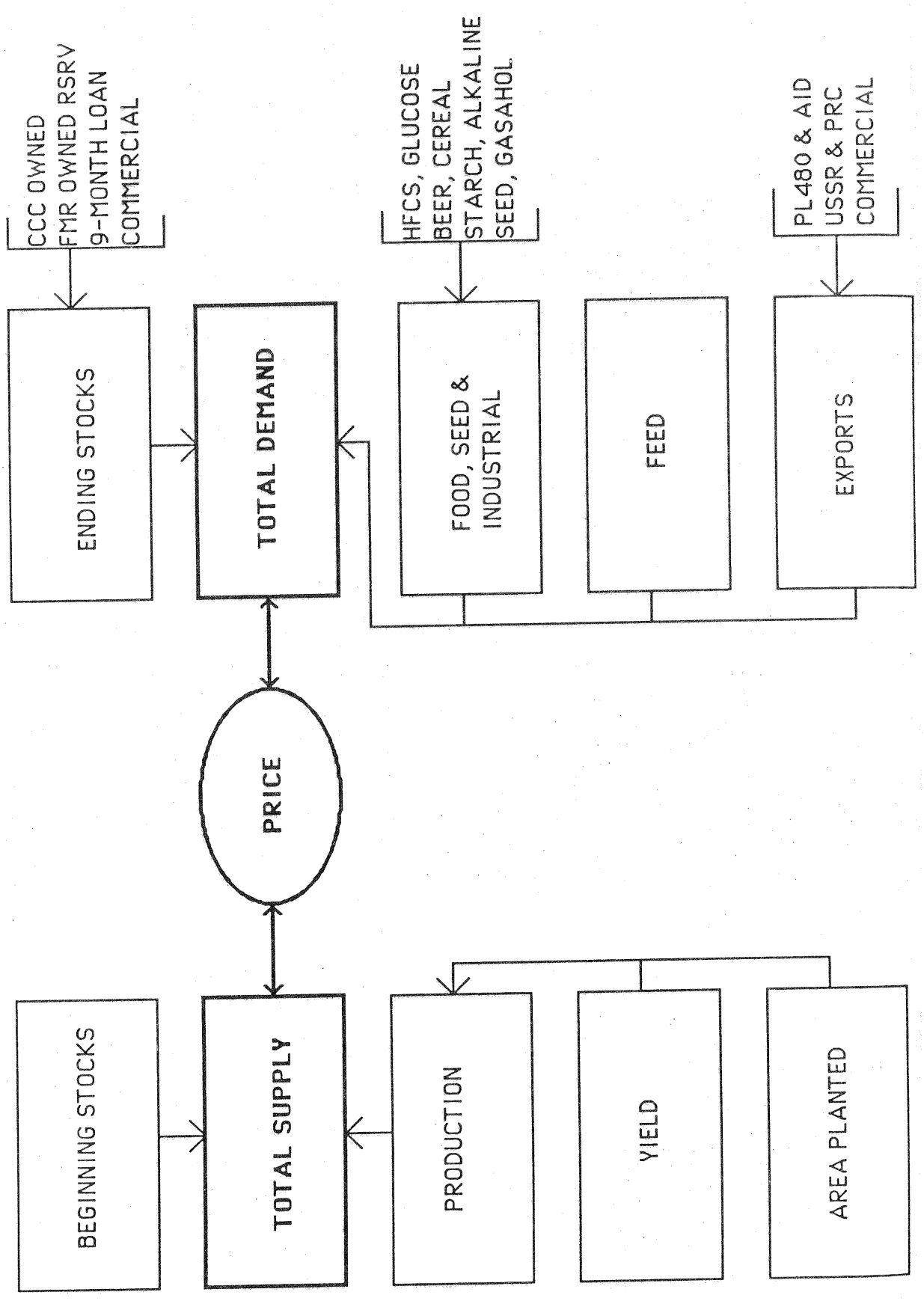

FIGURE 1. CORN MODEL PRODUCT FLOWS

TABLE 1: PER CAPITA MEAT CONSUMPTION PATHS UNDER THREE SCENARIOS

1. BASELINE[a]	1986	1987	1988	1989	1990	1991
Beef (pounds)	79.8	73.2	67.4	64.8	65.1	66.1
%	41	38	35	33	33	34
Pork	59.6	58.7	63.2	66.4	68.7	63.0
%	30	31	33	34	35	33
Chicken	56.8	60.2	61.9	62.9	63.7	64.7
%	29	31	32	32	32	33
Total	196.2	192.1	192.5	194.1	197.5	193.8
GCAU	91.21	92.32	94.06	99.54	99.12	97.05
HPAU	159.57	166.20	173.54	186.92	177.26	171.52

2. HIGH BEEF[b]	1986	1987	1988	1989	1990	1991
Beef	84.0	83.4	85.4	80.5	85.6	87.9
%	46	44	46	46	46	50
Pork	62.3	68.3	62.9	57.3	61.8	50.7
%	34	36	34	33	33	29
Chicken	36.3	36.1	37.9	37.0	37.1	36.8
%	20	19	20	21	20	21
Total	186.6	187.8	186.2	174.8	184.5	175.4
GCAU	100.36	99.12	95.92	96.16	88.87	93.01
HPAU	143.55	140.75	139.11	135.54	126.13	136.83

3. HIGH CHICKEN[c]	1986	1987	1988	1989	1990	1991
Beef	79.8	74.5	73.8	70.5	64.3	61.5
%	41	39	37	37	35	35
Pork	59.6	58.7	64.1	58.3	52.5	47.3
%	30	30	32	31	29	27
Chicken	56.8	60.2	60.0	61.9	65.2	65.8
%	29	31	30	32	36	38
Total	196.2	193.4	197.9	190.7	182.0	174.6
GCAU	89.27	87.38	84.97	83.72	80.74	79.76
HPAU	155.55	155.22	156.46	157.86	155.39	157.57

[a] The baseline scenario reflects the effects of current consumption patterns (generally declining demand for beef and pork, increasing chicken).

[b] This scenario is reproduced from consumption levels during the 1970-1975 period when beef consumption was relatively high and chicken low (but recognizing that total consumption is below the projected baseline level).

[c] This scenario drops beef and pork consumption over time and allows chicken to rise but absolutely and relatively (as a percent of the total bundle).

TABLE 2

SIMULATED PATHS OF SELECTED CORN AND SOYBEAN MEAL VARIABLES UNDER THE BASELINE[a]

	86/87	87/88	88/89	89/90	90/91	91/92
Exogeneous Assumptions						
GCAU	91.21	92.32	94.06	99.54	99.12	97.05
HPAU	159.57	166.20	173.54	186.92	177.26	171.52
			CORN			
Acreage						
Planted	76.6	67.8	65.7	64.0	64.8	65.9
Harvested	68.9	59.7	57.8	56.3	57.0	58.0
Yield	119.3	118.3	120.9	123.1	124.5	125.9
Supply						
Beginning Stocks (Mil.Bu.)	4,038	5,688	5,897	5,953	5,747	5,354
Production	8,223	7,065	6,990	6,930	7,101	7,300
Imports	3	2	1	1	1	1
TOTAL SUPPLY	12,264	12,755	12.888	12,884	12,848	12,655
Domestic Demand						
Feed	4,081	4,122	4,101	4,294	4,486	4,374
Food	913	933	957	978	999	1,024
Gasohol	250	260	270	280	290	200
Seed	18	18	17	17	18	18
TOTAL DOMESTIC	5,262	5,333	5,345	5,569	5,792	5,616
TOTAL DEMAND	6,576	6,859	6,935	7,137	7,494	7,398
Ending Stocks	5,688	5,896	5,953	5,747	5,354	5,257
Farm Price ($/Bu.)	$1.50	$1.64	$1.70	$1.85	$1.78	$1.82
			SOYBEAN MEAL			
Feed demand (Thou. Tons)	20133	20348	21137	23519	22731	22041
Meal price ($/Ton)	148	151	155	169	163	161

[a] Based on baseline meat consumption paths.

TABLE 3

SIMULATED PATHS OF SELECTED CORN AND SOYBEAN MEAL VARIABLES UNDER HIGH BEEF[b]

	86/87	87/88	88/89	89/90	90/91	91/92
Exogeneous Assumptions						
GCAU	100.36	99.12	95.92	96.16	88.87	93.01
HPAU	143.55	140.75	139.11	135.54	126.13	136.83
			CORN			
Acreage						
Planted	76.6	67.8	66.1	64.3	64.6	66.7
Harvested	68.9	59.7	58.2	56.6	56.8	58.7
Yield	119.3	118.4	120.8	122.9	124.6	125.6
Supply						
Beginning Stocks (Mil.Bu.)	4,038	5,108	5,010	5,085	5,197	5,514
Production	8,223	7,065	7,025	6,957	7,083	7,373
Imports	3	2	1	1	1	1
TOTAL SUPPLY	12,264	12,175	12.036	12,042	12,281	12,888
Domestic Demand						
Feed	4,650	4,545	4,220	4,086	3,853	4,324
Food	911	922	944	971	990	1,015
Gasohol	250	260	270	280	290	200
Seed	18	18	17	17	18	18
TOTAL DOMESTIC	5,829	5,745	5,451	5,354	5,151	5,357
TOTAL DEMAND	7,156	7,165	6,951	6,845	6,767	7,139
Ending Stocks	5,108	5,010	5,085	5,197	5,514	5,749
Farm Price ($/Bu.)	$1.80	$1.78	$1.76	$1.74	$1.53	$1.64
			SOYBEAN MEAL			
Feed demand	16755	16185	15067	13905	12990	12985
Meal price	148	110	115	117	120	122

[b] Based on the beef, pork, and chicken consumption paths of 1970-1975 simulated over the years 1986-1991.

TABLE 4

SIMULATED PATHS OF SELECTED CORN AND SOYBEAN MEAL VARIABLES UNDER HIGH POULTRY[C]

	86/87	87/88	88/89	89/90	90/91	91/92
Exogeneous Assumptions						
GCAU	89.27	87.38	84.97	83.72	80.74	79.76
HPAU	155.55	155.22	156.46	157.86	155.39	157.57
			CORN			
Acreage						
Planted	76.6	67.5	65.3	63.5	64.1	66.4
Harvested	68.9	59.4	57.5	59.6	56.4	58.4
Yield	119.3	118.5	121.0	123.2	124.8	125.7
Base Yield	105.6	108.6	110.4	114.6	115.6	117.2
Supply						
Beginning Stocks	4,038	5,802	6,284	6,865	7,508	8,153
Production	8,223	7,039	6,958	6,887	7,039	7,341
Imports	3	2	1	1	1	1
TOTAL SUPPLY	12,264	12,843	13,243	13,753	14,548	15,495
Domestic Demand						
Feed	3,963	3,819	3,542	3,400	3,385	3,304
Food	917	939	957	981	1,001	1,026
Gasohol	250	260	270	280	290	300
Seed	18	18	17	17	18	18
TOTAL DOMESTIC	5,148	5,036	4,786	4,678	4,694	4,648
TOTAL DEMAND	6,462	6,562	6,376	6,246	6,396	6,430
Ending Stocks	5,802	6,284	6,865	7,508	8,153	9,065
Farm Price	$1.48	$1.47	$1.44	$1.39	$1.34	$1.29
			SOYBEAN MEAL			
Feed demand	19098	21073	17489	17364	17906	16697
Meal price	148	153	149	148	158	152

[C] Based on increasing chicken consumption and decreasing beef and pork consumptions.

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