Generation of Probability Distributions on Farm Prices and Supply/Utilization Balances on Corn, Soybeans and Wheat for the Crops of 1989-91

by

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In recent years, increased attention has been given to the importance of risk management and the need for probability distributions of economic forecasts in agriculture. The case for generating the entire probability distribution in forecasts have been made by agricultural economists for many years (Teigen and Bell, Bessler and Moore, Nelson, Ikerd). Even so, the application of econometric models for probability forecasts has been quite limited. A major reason has been the extensive demands placed on models to generate such information (Armstrong). The purpose of this paper is to demonstrate that major stochastic variables can be incorporated in model output and provide useful information for decision makers. The effort being reported represents more of a beginning than a refined analytical procedure.

Acreage reduction programs in the U.S., in combination with the severe drought of 1988, have succeeded in substantially reducing U.S. stocks of grain and soybeans in the past three years. Carryover outside the U.S. has also been cut. The World Agricultural Outlook Board of the U.S. Department of Agriculture projected in March 1989 that world ending stocks of coarse grain and wheat for the 1988-89 crop year would be 17.6 percent of utilization, the lowest since the early 1970's (USDA, FAS). This indicates that the world will be more dependent on weather patterns for availability of these grains than has been the case for a decade and a half. Soybean carryover will also be low, virtually at pipeline levels. Variability of crop yields represents the most risky element in the agricultural outlook.

With the advent of commodity options markets, several researchers have developed procedures for translating premiums into implied volatility and incorporating that information into probability forecasts for the year ahead in a risk management framework (King, et al., Hilker and Black). Alternative procedures have been explored using the performance of the futures market over time and basis patterns to generate probability forecasts of cash prices (Ferris).

However, economic projections are essential for more than a year into the future and beyond the range of futures contracts. Very little effort has been expended by agricultural economists forecasting several years into the future in a probabilistic mode year by year. Difficult as it is to accomplish, we need to try.

AGMOD

"AGMOD", an econometric model of U.S. agriculture recently developed at Michigan State University, has been used to generate point forecasts year by year to the year 2000. The model includes feed grain, wheat and the soybean sector and principle livestock and poultry enterprises. The international component consists of the major

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exporting nations and the rest of the world. A general schematic of AGMOD is presented in Figure 1.[1/]

The model currently has 218 equations, of which 55 are behavioral and 163 are transformations. Most of the statistical relationships were based on annual data for 1962 to 1987 or 1988. AGMOD is primarily recursive with a simultaneous solution focusing on the real U.S. farm price of grain and soybeans. The model was developed with Micro TSP software and uses the Gauss-Seidel solution method (Hall and Lilien).

Because the 5.0 and later versions of Micro TSP have an upper limit of 300 variables, AGMOD was kept as simple as possible concentrating on the most salient variables. The entire model--database, work file and edit file--is on one floppy disk. Solving for a 12-year projection period generally requires about three to four minutes.

Because Micro TSP has a random number generator that returns a normal distribution, a plausible modification of AGMOD was to explore the results if crop yields were entered stochastically. The model includes six crop yield variables:

1. U.S. corn
2. U.S. soybeans
3. U.S. wheat
4. Coarse grain outside the U.S.
5. Wheat outside the U.S.
6. Soybeans in Argentina and Brazil

Projections of these yields in the base model have been simply linear functions of time, i.e., trend yields.

Conversion to Stochastic Yields

The first step in the conversion to a stochastic model was to test whether the assumption of linear trends in yields was appropriate. While yields have not increased linearly in the long-run, such as back to the early part of the century, the pattern since 1960 has been close to linear. This was indicated by the application of a double exponential smoothing program which produced fairly linear functions for the 1960-87 period. Because of the extreme drought, 1988 was excluded from the analysis in establishing the trend.

While the 1960-87 period was used for yields 1-5, the 1972-88 period was selected for South American soybean yields. The earlier years were not included because the crop was of minor importance there at that time.

Inspection of the deviations of yields from trend indicated a tendency for the absolute variation to increase over time--as the level of yield increased. This phenomenon has been observed by a number of analysts and efforts have been made to

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[1/] A detailed description of the model will appear in the Proceedings of the 1988 AAEA Pre-Conference Symposium on "Large Scale Models and Economic Policy Analysis."

determine the causes (Hazell). For this reason, the decision was made to construct variables representing a ratio of actual to trend yields rather than absolute deviation. The amplitude of the ratio was more consistent over time than the absolute deviation. Even so, on U.S. corn and soybeans, a case could be made for increasing <u>relative</u> instability. The standard deviation of yields as a pecent of trend was 10.3 percent on U.S. corn, 7.2 percent on U.S. soybeans, 6.3 percent on U.S. wheat, 3.1 percent on coarse grain outside the U.S., 5.1 percent on wheat outside the U.S. and 9.2 percent on South American soybeans.

Possibly, the weakest part of this analysis is the assumption that ratios of yield to trend are normally distributed. Some support to the normality assumption can be gleaned from the central limit theorem. As stated by Hazell, "...the central limit theorem suggests that national yields could be approximately normally distributed even if farm yields are highly skewed." (Hazell) The highly aggregative yields on coarse grains and wheat outside of the U.S. do reflect this theorem, but corn and soybean yields within the U.S. are increasingly displaying skewness to the downside. However, Micro TSP only allows one to employ normal distributions.

Another problem encountered was the positive correlations among the six yield variables. Particularly strong were the relationships between deviations in the yields of corn and soybeans in the U.S. (correlation coefficient of .775) and yields of coarse grains and wheat outside the U.S. (correlation coefficient of .715). Of secondary concern was the correlation between deviations in corn and wheat yields in the U.S. (.241) and between wheat yields in the U.S. and outside (.206).

The following procedure was adopted. The yield of corn in the U.S. was generated by trend yield plus or minus normal distribution of the ratio of actual to trend, encompassing the standard deviation based on 1960-88 data. Specifically the function was:

RYCNF = 1.000 + .1017885 * NRND

where:

RYCNF = forecast value of ratio between actual and trend yield on corn.

NRND = random number generator for a normal distribution with a mean of zero and a variance of one.

The above equation was included in the program for the model along with:

YCNF = -3931.70 + 2.037542 * TIME

YCN = YCN * (TIME = <1988) + YCNF * (TIME >1988) * RYCNF

where:

YCNF = trend yield on corn in the U.S. (bu./acre).

YCN = actual yield on corn in the U.S. for years equal to and prior to 1988; and after 1988, the trend yield times the ratio to trend derived from the randomly distributed normal variable (bu./acre).

An identical procedure was used to generate coarse grain yields outside the U.S.

Because soybean yields in the U.S. are strongly correlated with corn, the ratio of soybean yields to trend was established as a linear function of the ratio of corn yields to trend as follows:

$$RYSBF = .457124 + .542445 * RYCNF + DEVYSB$$

$$DEVYSB = .0455866 * NRND$$

where:

RYSBF = forecast value of the ratio between actual and trend yield on soybeans.

DEVYSB = standard error of the regression on RYSBF times the random number generator for a normal distribution.

The equation for RYSBF was estimated by ordinary least squares. In testing the correlation between RYSBF and RYCNF, this procedure provided the means to simulate the relationship found in the correlation matrix for these two variables in 1960-88.

By the same procedure, the ratio to trend yields on wheat was derived from RYCNF. The ratio to trend yield on wheat outside of the U.S. was a function of the ratio of yields to trend on coarse grain outside of the U.S. and U.S. wheat yields plus the standard error of the equation times the random number generator. Because soybean yields in South America were not correlated with other yields, the procedure was identical with that for corn in the U.S.

With these modifications in the base model, a separate program was written to run the model repeatedly and store the output on a disk file. For this particular analysis, the results from 100 runs of the model were arbitrarily selected. Because the procedure allows for variation in yields, the time for a single solution for the 12-year projection period averaged six to seven minutes, three minutes longer than when trend yields were assumed. About 11 hours were required to solve the model 100 times.

Results From Model Runs

Results for the three crop years of 1989-91 were singled out for presentation. Economic growth in the U.S. is presumed to slow down into 1990 and then proceed at a pace amounting to 1 percent per year increases in real disposable income per capita. Similar growth rates are projected for the rest of the world. Inflation in the CPI will average 3-4 percent per year. The Feed Grain and Wheat Programs will continue as developed in the Food Security Act of 1985 with loan rates and target prices held at the scheduled 1990 nominal levels for the decade of the 1990's. The Conservation Reserve is presumed to reach the objective 45 million acres early in the 1990's.

Built into AGMOD is a mechanism for establishing set-aside levels for corn and wheat based on ending stocks to utilization ratios of the previous crop year. Also, exports of U.S. feed grains and wheat are automatically increased if ending stocks outside the U.S. reach precariously low levels. In addition, low U.S. ending stocks can trigger some release from the contracts under the Conservation Reserve Program.

The results of the 100 runs are presented in Tables 1-17 which include probability distributions on the key variables, as well as the output when trend yields are assumed. Except for utilization of feed grain for livestock feed, domestic utilization was omitted because of the inelastic nature of the demands. Exports, on the other hand, are highly dependent on yields abroad.

Corn

Because acreage harvested for corn is highly dependent on the Feed Grain Program and previous years' prices, the stochastic model forecast for harvested acreage in 1989 is the same as for the trend model--about 67 million acres (Table 1). While conditions which could cut yields might also lead to abandonment of planted acres, this was not allowed in the model. Unless yields are particularly high, no set-aside will be required in 1990 and acreage will likely increase to the 70-72 million acre range. Chances are two out of three that acreage will remain at least that high in 1991.

Note in Table 1 that the trend yield model projects harvested acres of corn at 71 million acres in 1991. However, the probability model indicates that the chances that harvested acreage will be between 70 and 72 million acres is only 15 percent. For decision makers, the probability forecast would seem to be much more valuable than the point forecast--or at least both types of forecasts should be presented.

Production in 1989 centers on the 8 billion bushel level with about an 80 percent probability of being between 7 billion and 9 billion bushels (Table 2). Along with acreage, the distribution shifts upward in 1990 and 1991.

While the standard deviation for production is about 10 percent of the mean in 1989, given the harvested acreage level, the standard deviation for domestic feeding is much less--at about 2-3 percent of the mean in the short-run (Table 3). This is because of limited opportunity to modify livestock numbers within a year and limitations on changing feed rations. For these reasons, nearly 80 percent of the observations on feed utilization by livestock fell in the range of 140-146 million MT in 1989. This distribution could widen out over time as livestock producers respond to changing profit levels. Only modest changes are predicted for the 1990-91 in this analysis, however.

Exports, on the other hand, could vary over a fairly wide range (Table 4). While the most likely level, as forecasted by AGMOD, is 60-65 million MT in 1989, the standard deviation around this amount establishes a range from 50 to 75. The standard deviation would be about 20 percent of the mean. The trend yield version of the model predicts a sharp increase in exports in 1991 which is also reflected in the probability distribution.

On feed grain, ending stocks seldom dip below 15 percent of annual utilization. Since 1960, this only happened in the early 1970's. In terms of projected utilization for 1989-91, 15 percent would amount to ending stocks around 35-40 million MT. From Table 5, the chances of that occurring are about one in five. A surplus would emerge if ending stocks reach 30 percent of annual use, a serious surplus at 50 percent of annual use or more. This would mean ending stocks at 80 to 135 million MT. The probability of a minor surplus problem is about 17 percent in 1989, 22 percent in 1990 and 29 percent in 1991. Chances are very slim for a major surplus problem on feed grain in 1989-91. Most likely stocks will remain in the 50-80 million MT range.

Farm prices on corn are expected to remain in the mid $2.00-3.00 range, easing in 1990 and strengthening in 1991 (Table 6). The distribution is skewed to the top side as more clearly seen in Figure 2. The "spreading out" of the distribution in 1990 and 1991 is not surprising in view of additional stochastic influences on acres harvested in those years compared with 1989.

Soybeans

Like corn, acres harvested for soybeans in 1989 are largely predetermined--in this example at 61 million acres (Table 7). An expansion is forecast in the trend model for 1990 and 1991. Chances are very small that harvested acres will decline. The distribution does spread out noticeably in 1991. While the trend model establishes the area at 69 million acres, in line with the most likely range in the probability model, there is about one chance out of three that the area will be lower and a comparable chance the area will be higher. A similar pattern can be noted on production of soybeans which encompasses the variability of both acres and yields after 1989 (Table 8).

For 1989, the probability is high that soybean exports will be in the range of 700-850 million bushels (Table 9). This remains the predominant range in 1990 with an increase and spreading out portrayed in Table 9 for 1991. Probabilities are greater than 50 percent that exports will be above 850 million bushels in 1991.

Since 1960, the lowest level experienced for ending stocks of soybeans was about [illegible] percent of annual use back in 1964. In 1989-91, 4 percent of annual use would be equivalent to about 80-90 million bushels. As evident in Table 10, both the probability and trend yield models point to extremely low carryover in 1989 and 1990 with remaining tightness in 1991 very likely. For carryover to reach surplus proportions of 20 percent of annual use or more, ending carryover would have to build to levels over 400 million bushels. That possibility is extremely unlikely in 1989-91.

The low ending stock levels projected by AGMOD are not likely to be realized. The reason is that models of this type have difficulty in shutting down utilization in periods of tight supplies. The price of meal and oil is the major mechanism for rationing supplies in the model; and while we believe this to be relevant in the "real world," the trade, being aware of impending tightness, apparently makes adjustments independent of prices to avoid an unusually sharp run up in price.

A major component in the model in deriving the price of soybeans is a nonlinear relationship with the ending stock-utilization ratio. For the solution procedure to operate effectively, a lower bound must be put on this ratio. For this reason, the upper portions of the price distribution are somewhat truncated (Table 11 and Figure 3). The probability model puts the farm price of the 1989 soybean crop in the $7.00-8.50 range with a likelihood of two-thirds. Prices are projected to strengthen into 1990 and 1991. The USDA has estimated that the total production costs, including fixed costs, are around $5.60 per bushel with trend yields (USDA, Agricultural Outlook). Probabilities are very high that soybean growers will cover total costs in 1989-91.

The distribution on soybean prices does flatten out in 1990 and even more in 1991 (Figure 3). These price distributions, in combination with corn, could be incorporated in models for crop farmers in establishing "risk-rated" rotation plans. The corn and soybean meal component would be useful for livestock producers in developing their "risk-rated" budgets.

Wheat

Some special problems arose in modeling wheat with stochastic yields. The area for harvest in 1989 is well established at around 60-62 million acres (Table 12). For 1990, however, an upper limit was placed on harvested area of wheat at 71 million acres. The extremely low carryover projected as likely for 1989 triggers no set-aside requirements for 1990 in 84 percent of the trials. This drives acreage up to the 68-72 million acre range, but no higher. The upper limit is removed in 1991 and a mechanism initiated to bring ending stocks up to 25 percent of annual utilization--about 700-800 million bushels.

Under the low stock scenarios, some land would likely be pulled out of the Conservation Reserve. The mechanism in the model to protect ending stocks may have resulted in a too great and abrupt increase in area. A 21 million acre increase from 62 to 83 million acres as forecast in the trend models does have parallels in the past, but doesn't happen often (Table 12). The distribution for area harvested in 1991 is bimodal, with a 20 percent chance that acreage expansion will not be needed.

The trend yield for U.S. wheat for 1989 was 38.8 bushels per acre and was not modified by the concerns about the drought in the hard winter wheat areas. If the drought is discounted, the probability is high that the 1989 crop will be between 2.2 and 2.6 billion bushels (Table 13). That distribution flattens out in 1990 centering on the 2.4 to 2.8 billion bushel range. The probabilities for 1991 are about one in four that production will ease back to the 2.2-2.8 billion bushel range or 70 percent that production will exceed 3.0 billion bushels. A 3 billion bushel crop would exceed the previous record in 1981 of 2.8 billion bushels.

The driving force behind the acreage and production increase likely in 1990 and 1991 is the expanding exports (Table 14). Note, however, the relatively high dispersion of the distribution, especially in 1990 and 1991. The standard deviation in 1990 relative to the mean is about 20 percent on the downside and 12 percent on the upside.

The probability distribution on ending stocks points to the strong likelihood of tight supplies in 1989-91 (Table 15). Seldom have U.S. wheat stocks dropped below 20 percent of utilization--equivalent to about 600 million bushels in 1989-91. Probabilities that stocks will be below that level are about 91 percent for 1989, 84 percent for 1990 and 69 percent for 1991. For stocks to be considered large, carryover would have to increase to 1.5-2.0 billion bushels, an event with very low probability in 1989-91.

The ending stock-utilization ratio is a major component in the wheat price equation, and prices reflect an inverse nonlinear relationship. As with both corn and soybeans, the lower the stock-utilization ratio, the higher the price. The price effect accelerates at low stock levels because of the increasing anxiety about shortages of a major staple. This anxiety is reflected in the price distribution for 1990 which is bimodal concentrating on the 1989 price level and above $5.80 per bushel.

A classic example of the meaningless of means is presented in Table 16 and Figure 4. Trend yields project a farm price on wheat in 1990 of $4.85 per bushel. However, the probability of this price (in the range of $4.60-4.99) is only 4 percent. The model indicates almost a 40 percent chance the price will be $5.80 or higher and a 44 percent chance the price will be lower than $4.20. Response to relatively high prices in 1990 would bring prices back down in 1991--with the probability of 50 percent that prices would be below $3.80 per bushel.

An important caveat in this scenario on wheat is that the implementation of the Export Enhancement Program was not explicitly modeled. The expenditures for this program would undoubtedly be curtailed should stocks decline as portrayed as likely in Table 15. Such action would hold stocks above the projected level. On the other hand, one reason the EEP was not included in AGMOD was the fact that the model predicted wheat exports satisfactorily without incorporating EEP. Regardless, the feedback from the 100 runs of AGMOD suggests to the modelers that some reformulation of the wheat sector of the model is appropriate. Certain deficiencies surfaced which were not apparent when trend yields were assumed.

A Long-Term Global View

As mentioned at the beginning of the paper, prospects are that world stocks of coarse grains and wheat will be at the lowest level since the early 1970's at the beginning of the 1989-90 crop year--at about 17-18 percent of annual utilization. The lowest on record since 1960 was about 16 percent in 1973 and 1974. What are the probabilities that world ending stocks will drop below 16 percent of utilization in 1989-91? Based on stochastic AGMOD, this probability would be 41 percent in 1989, 63 percent in 1990 and 64 percent in 1991 (Table 17). The trend yield projections are 15, 14 and 14 percent ending stocks in 1989-91, respectively.

While only the 1989-91 crop years are reported in Tables 1-17, projections from AGMOD were generated for the entire decade of the 1990's. An analysis of world ending stocks of coarse grains and wheat as a percent of utilization indicated a much higher probability of tight grain supplies than surpluses, although both situations could emerge. In 1989-94, the probability that ending stocks drop below 12.5 percent of utilization is about 85-90 percent, while the chances that stocks increase to levels above 20 percent is only 6 percent. The 20 percent level would be close to the long-term average and well below the 30.7 percent record in 1986-87.

In 1995-2000, the probability of ending stocks below 12.5 percent of annual use is about 75-80 percent and chances of stocks above 20 percent is about 50 percent. The model points to some chance for serious surplus problems in the latter part of the 1990's.

Conclusions

The purpose of this paper was to demonstrate the possibilities of stochastic modeling as related to the major unpredictable element in agriculture--crop yields. New software for microcomputers provides the means to encompass this variability and generate probability forecasts useful for decision makers. While additional time and resources are required, routine procedures can be developed to facilitate probabilistic forecasting. Such information can be combined with farm level models to provide a framework for risk management in long-range planning.

Additional research is needed to refine the process. As indicated earlier, incorporation of nonnormal distributions of yield variations needs to be explored. AGMOD needs to be reformulated to handle extreme situations, particularly scenarios with low level stocks and high prices. As presently designed, AGMOD does not provide explicitly for increase of inputs per acre, such as fertilizer, in response to crop prices.

AGMOD output may appear somewhat optimistic relative to exports and farm prices for 1989-91--at least this tendency has been observed relative to some other models. However, alternative assumptions can easily be incorporated to analyze the probability prospects under a somewhat less robust agricultural economy.

The value of a model such as this is that it provides modelers with a way to abstract from a very complex world, interject their own subjective view of the world and see what the model spins out. Iteratively, between the model and the modeler and interactively between the modeler and others who can expand the modeler's vision, analytical tools are sharpened.

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Table 1. Probability Distribution on Acres Harvested for Corn in the U.S. Compared with Trend Yield Assumptions

Acres Harvested Million Acres	1989	1990	1991
		Percent	
Less than 60.0	0	0	0
60.0-61.9	0	1	4
62.0-63.9	0	4	2
64.0-65.9	0	10	4
66.0-67.9	100	10	14
68.0-69.9	0	5	5
70.0-71.9	0	51	15
72.0-73.9	0	19	26
74.0-75.9	0	0	15
76.0 and over	0	0	15
Total	100	100	100
		Million Acres	
Acres harvested based on trend yields	67	71	71

Table 2. Probability Distribution on Corn Produ in the U.S. Compared with Trend Yield Assump

Production Billion Bushels	1989	1990
		Percent
Less than 5.00	0	0
5.00-5.49	0	0
5.50-5.99	0	1
6.00-6.49	3	0
6.50-6.99	4	3
7.00-7.49	20	14
7.50-7.99	18	11
8.00-8.49	20	28
8.50-8.99	20	17
9.00-9.49	11	17
9.50-9.99	4	7
10.00-10.49	0	2
10.50-10.99	0	0
11.00 and over	0	0
Total	100	100
		Billion Bushels
Production based on trend yields	8.00	8.61

Table 3. Probability Distribution on Utilization of Feed Grain for Livestock in the U.S. Compared with Trend Yield Assumptions

Feed Utilization Million M.T.	1989	1990	1991
		Percent	
Less than 134.0	2	2	2
134.0-135.9	3	0	1
136.0-137.9	3	8	5
138.0-139.9	11	8	6
140.0-141.9	15	16	16
142.0-143.9	39	39	21
144.0-145.9	25	23	27
146.0-147.9	1	4	20
148.0 and over	0	0	2
Total	100	100	100
		Million M.T.	
Utilization of feed grain for livestock based on trend yields	142	143	143

Table 4. Probability Distribution on Exports o Feed Grain in the U.S. Compared with Trend Yield Assumptions

Exports Million M.T.	1989	1990
		Percent
Less than 40.0	1	0
40.0-44.9	3	1
45.0-49.9	11	5
50.0-54.9	9	9
55.0-59.9	11	11
60.0-64.9	24	12
65.0-69.9	14	19
70.0-74.9	12	13
75.0-79.9	12	14
80.0 and over	3	16
Total	100	100
		Million M.T.
Exports based on trend yields	65	70

Table 5. Probability Distribution on Ending Stocks of Feed Grain in the U.S. Compared with Trend Yield Assumptions

Ending Stocks Million M.T.	Year 1989	 1990	 1991
		Percent	
Less than 20	4	2	2
20-29	5	8	6
30-39	10	10	8
40-49	9	8	11
50-59	19	16	13
60-69	18	20	14
70-79	18	14	17
80-89	11	9	9
90-99	2	6	11
100-109	4	4	6
110 and over	0	3	3
Total	100	100	100
		Million M.T.	
Ending stocks based on trend yields	56	63	58

Table 6. Probability Distribution of the U.S. Farm Price of Corn Compared with Trend Yield Assumptions

Price $/Bushel	Year 1989	 1990	 1991
		Percent	
Less than 2.00	3	8	5
2.00-2.29	20	20	20
2.30-2.59	38	32	27
2.60-2.89	17	16	20
2.90-3.19	12	12	13
3.20-3.49	4	9	6
3.50-3.79	2	1	2
3.80-4.10	3	0	5
4.10 and over	1	2	2
Total	100	100	100
		$/Bushel	
Price based on trend yields	2.63	2.51	2.71

Table 7. Probability Distribution on Acres Harvested for Soybeans in the U.S. Compared with Trend Yield Assumptions

Acres Harvested Million Acres	Year 1989	 1990	 1991
		Percent	
Less than 58.0	0	0	0
58.0-59.9	0	1	1
60.0-61.9	100	20	2
62.0-63.9	0	68	11
64.0-65.9	0	11	13
66.0-67.9	0	0	15
68.0-69.9	0	0	24
70.0-71.9	0	0	22
72.0-73.9	0	0	9
74.0-75.9	0	0	3
76.0 and over	0	0	0
Total	100	100	100
		Million Acres	
Acres harvested based on trend yields	61	64	69

Table 8. Probability Distribution on Soybean Production in the U.S. Compared with Trend Yield Assumptions

Production Billion Bushels	Year 1989	 1990	 1991
		Percent	
Less than 1.70	2	0	0
1.70-1.79	6	4	0
1.80-1.89	14	13	2
1.90-1.99	37	20	9
2.00-2.09	19	23	8
2.10-2.19	14	20	15
2.20-2.29	8	15	23
2.30-2.39	0	4	13
2.40-2.49	0	1	12
2.50-2.59	0	0	11
2.60 and over	0	0	7
Total	100	100	100
		Billion Bushels	
Production based on trend yields	1.99	2.10	2.29

Table 9. Probability Distribution on Exports of Soybeans in the U.S. Compared with Trend Yield Assumptions

Exports Million Bushels	Year 1989	1990	1991
		Percent	
Less than 650	0	3	1
650-699	2	12	0
700-749	22	22	4
750-799	35	31	17
800-849	32	20	21
850-899	7	7	22
900-949	2	3	21
950-999	0	2	10
1000 and over	0	0	4
Total	100	100	100
		Million Bushels	
Exports based on trend yields	736	769	882

Table 10. Probability Distribution on Ending Stocks of Soybeans in the U.S. Compared with Trend Yield Assumptions

Ending Stocks Million Bushels	Year 1989	1990	1991
		Percent	
Less than 50	43	48	37
50-99	29	18	9
100-149	13	14	16
150-199	8	10	19
200-249	3	7	6
250-299	3	3	10
300 and over	1	0	3
Total	100	100	100
		Million Bushels	
Ending stocks based on trend yields	59	81	126

Table 11. Probability Distribution of the U.S. Farm Price of Soybeans Compared with Trend Yield Assumptions

Price $/Bushel	Year 1989	1990	1991
		Percent	
Less than 5.50	1	3	1
5.50-5.99	5	3	4
6.00-6.49	11	9	5
6.50-6.99	8	9	10
7.00-7.49	16	11	15
7.50-7.99	34	14	16
8.00-8.49	18	21	10
8.50-8.99	4	21	12
9.00-9.49	3	7	17
9.50 and over	0	2	10
Total	100	100	100
		$/Bushel	
Price based on trend yields	7.81	8.02	8.12

Table 12. Probability Distribution on Acres Harvested for Wheat in the U.S. Compared with Trend Yield Assumptions

Acres Harvested Million Acres	Year 1989	1990	1991
		Percent	
Less than 60.0	0	2	3
60.0-63.9	100	14	10
64.0-67.9	0	0	7
68.0-71.9	0	84	0
72.0-75.9	0	0	3
76.0-79.9	0	0	15
80.0-83.9	0	0	14
84.0-87.9	0	0	17
88.0 and over	0	0	31
Total	100	100	100
		Million Acres	
Acres harvested based on trend yields	62	69	83

Table 13. Probability Distribution on Wheat Production in the U.S. Compared with Trend Yield Assumptions

Production Billion Bushels	1989	1990	1991
		Percent	
Less than 2.00	0	0	0
2.00-2.19	6	3	1
2.20-2.39	51	13	7
2.40-2.59	34	30	9
2.60-2.79	8	29	7
2.80-2.99	1	18	6
3.00-3.19	0	7	10
3.20 and over	0	0	60
Total	100	100	100
		Billion Bushels	
Production based on trend yields	2.42	2.70	3.32

Table 14. Probability Distribution on Exports of Wheat in the U.S. Compared with Trend Yield Assumptions

Exports Million Bushels	1989	1990	1991
		Percent	
Less than 1100	0	0	1
1100-1199	1	1	0
1200-1299	5	4	3
1300-1399	13	9	4
1400-1499	24	7	5
1500-1599	20	5	3
1600-1699	16	13	9
1700-1799	14	13	6
1800-1899	5	15	6
1900-1999	1	12	13
2000-2099	0	14	19
2100-2199	1	4	9
2200-2299	0	3	9
2300 and over	0	0	13
Total	100	100	100
		Million Bushels	
Exports based on trend yields	1586	1815	2019

Table 15. Probability Distribution on Ending Stocks of Wheat Compared with Trend Yield Assumptions

Ending Stocks Million Bushels	1989	1990	1991
		Percent	
Less than 100	7	40	8
100-199	22	11	6
200-299	19	8	23
300-399	19	13	9
400-499	15	8	8
500-599	9	4	15
600-699	6	6	10
700-799	1	6	10
800-899	0	2	4
900-999	1	2	3
1000 and over	1	0	4
Total	100	100	100
		Million Bushels	
Ending stocks based on trend yields	311	183	426

Table 16. Probability Distribution of the U.S. Farm Price of Wheat Compared with Trend Yield Assumptions

Price \$/Bushel	1989	1990	1991
		Percent	
Less than 2.60	2	7	8
2.60-2.99	8	8	19
3.00-3.39	12	8	12
3.40-3.79	17	7	11
3.80-4.19	18	14	9
4.20-4.59	13	4	15
4.60-4.99	10	4	12
5.00-5.39	9	4	5
5.40-5.79	5	5	2
5.80 and over	6	39	7
Total	100	100	100
		\$/Bushel	
Price based on trend yields	4.01	4.85	3.79

Table 17. Probability Distribution of the World Ending Stocks of Coarse Grain and Wheat as a Percent of Total Utilization Compared with Trend Yield Assumptions

Stocks Relative to Utilization	Year		
Percent	1989	1990	1991
		Percent	
Less than 10	1	3	4
10	0	5	3
11	4	9	6
12	6	13	13
13	6	11	12
14	12	12	10
15	12	10	16
16	13	11	9
17	16	5	11
18	14	13	6
19	8	1	4
20	7	4	3
21 and over	1	3	3
Total	100	100	100
		Percent	
Stocks relative to utilization based on trend yields	15	14	14

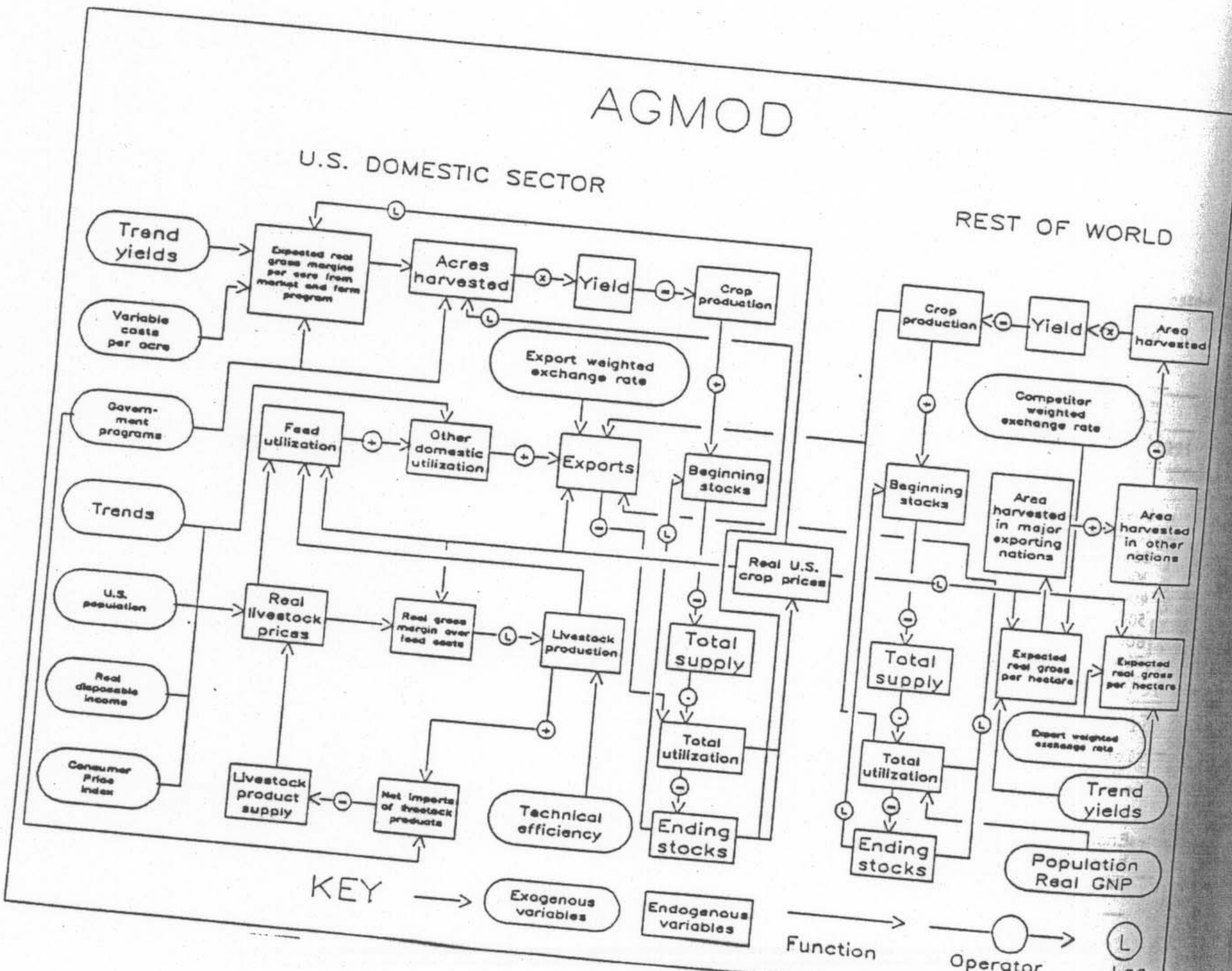

Figure 1

PROBABILITY DISTRIBUTIONS FOR THE FARM PRICE OF THE 1989-91 CORN CROPS IN 30 CENT PER BU. INTERVALS CENTERED ON THE INDICATED PRICE

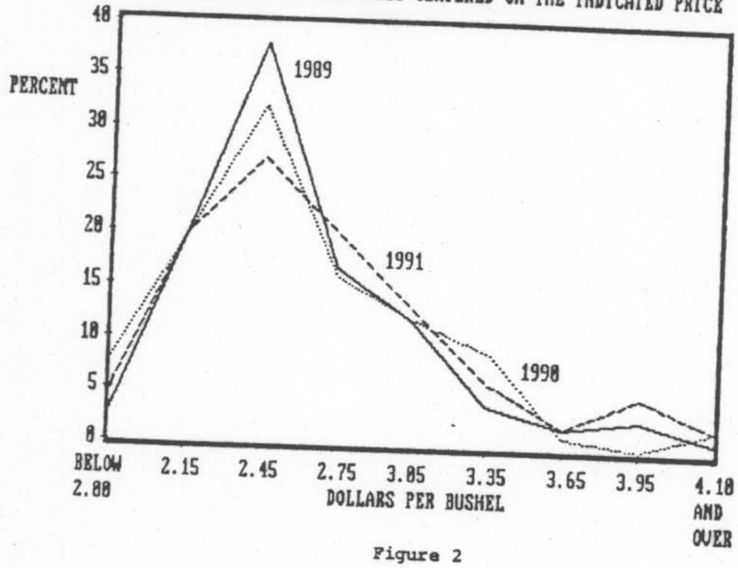

Figure 2

PROBABILITY DISTRIBUTIONS FOR THE FARM PRICE OF THE 1989-91 SOYBEAN CROPS IN 50 CENT PER BU. INTERVALS CENTERED ON THE INDICATED PRICE

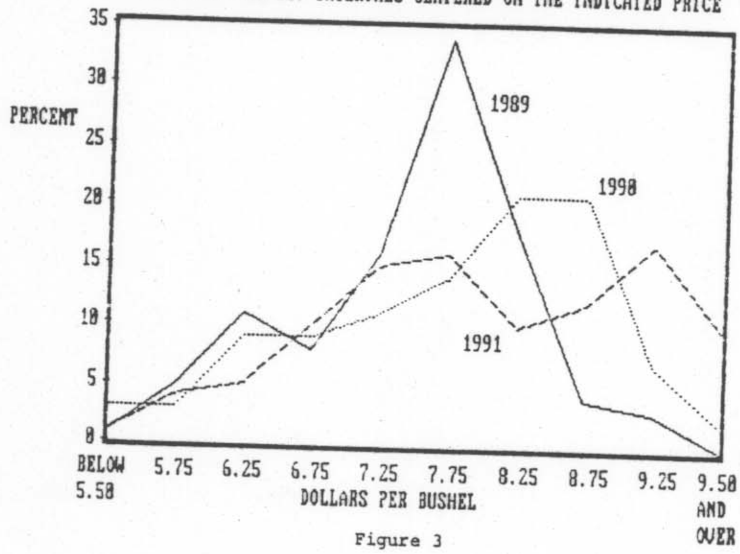

Figure 3

PROBABILITY DISTRIBUTIONS FOR THE FARM PRICE OF THE 1989-91 WHEAT CROPS IN 40 CENT PER BU. INTERVALS CENTERED ON THE INDICATED PRICE

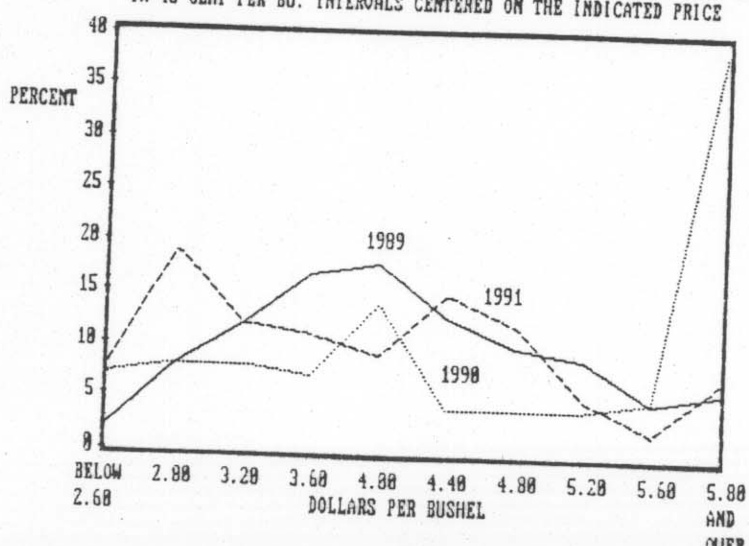

Figure 4