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(Abstract)

Implications of Uncertainty in Yields and Exports

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A prototype procedure is presented for developing subjective, probabilistic evaluations for future uncertainties about commodity yield and export expectations. The subjective uncertainty information is incorporated into a large multicommodity systems model in order to estimate future commodity price uncertainties that are useful for public policy and program decisions in agriculture.

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Introduction

From the second world war until the seventies, U.S. farm prices have largely been sheltered from the impacts due to the vagaries of weather. Domestic stocks were sufficient to meet substantial and unforecasted export demands or declines in yields. Two such examples are the high export shipments of 1965-66 and the corn blight conditions of 1971.

During the last few years, actual outcomes of yields and exports significantly affected farm prices, incomes and government costs. More uncertainty is in store for the future. Some climatologists argue that we are entering another ice age, drought cycle, or other adverse climatic condition, indicating a change in direction to low yields, high exports and high farm prices. Others argue that "normal" weather is the only reasonable assumption for planning purposes; whereupon the definition of "normal" is questioned. The complex relationships linking solar, stellar and orbital patterns to weather are unknown. Neither are the relationships between weather and yields known. There is more general agreement that planning should include consideration of year-to-year fluctuations in yields and exports.

The purpose of this paper is two-fold. First, it provides a prototype of how one could combine statistical analysis with commodity analysts' judgments to obtain a perception regarding the distributions of uncertainty in yields and exports. And second, it shows a graphical approach for reporting the implications on prices from a comprehensive inter-commodity analysis.

Uncertainty in Yields and Exports

Distributional assumptions concerning stochastic terms may strongly influence applied research results. Normally distributed errors are commonly used in econometric studies to represent uncertainty. They show central tendency and are defined from negative to positive infinity. A single observation drawn sufficiently far out in either tail affects one's ability to effectively communicate credible results. Truncating at two or three standard deviations is common practice as a guard against such troublesome observations; however, symmetry about the mode is preserved. Skewness can be particularly important to policy officials as one side of the distribution may be perceived to be more likely than the other. For example, poor weather may significantly affect yields, whereas exceptionally good weather may not be as important.

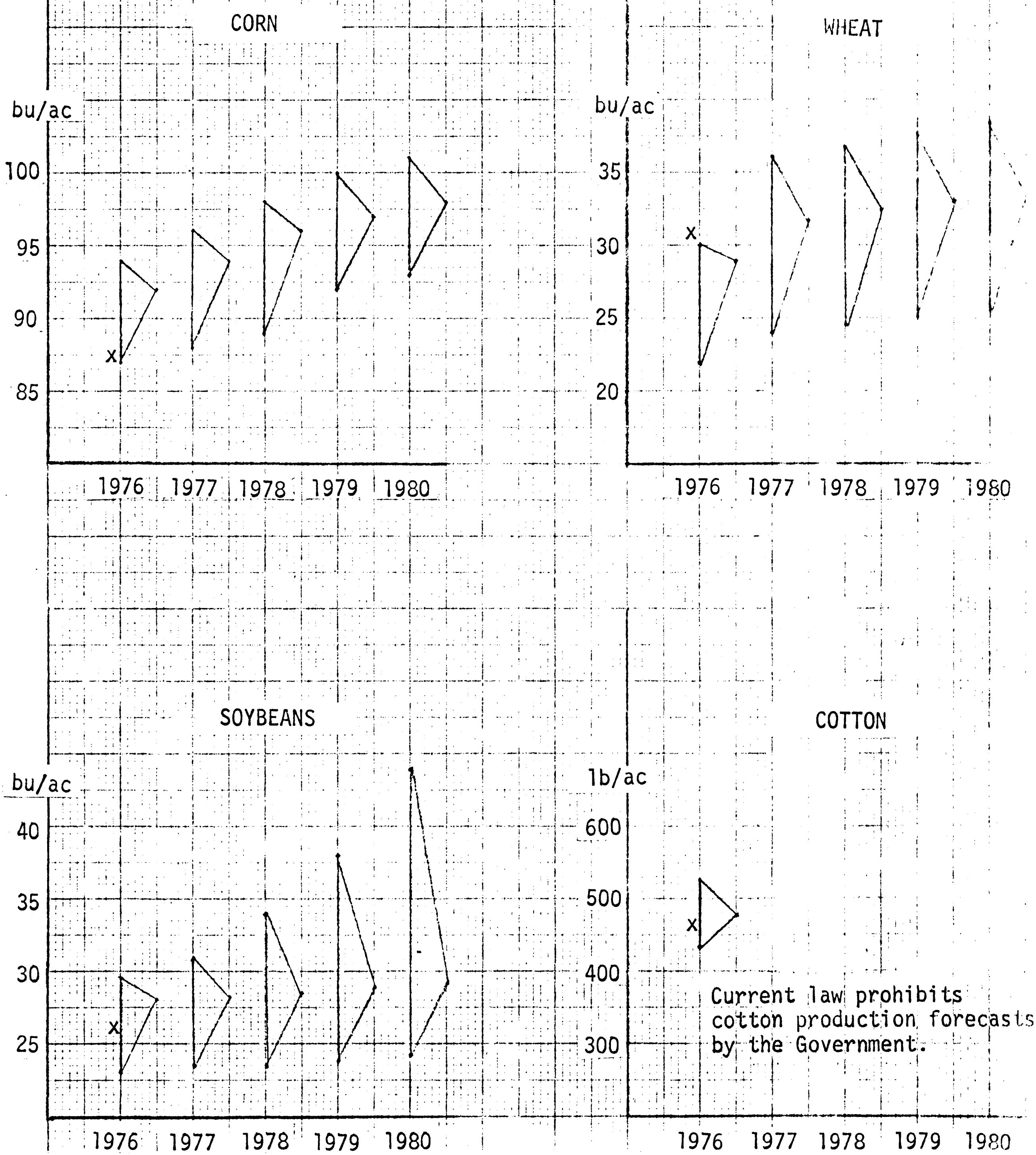
A simple operations research tool, the triangular distribution, was used to represent perceived uncertainties in important variables (Fishman, 1973; Taylor and North, 1976). It is based on estimates of the minimum, modal and maximum values. Such estimates are roughly consistent with the analysts' current understanding regarding the true probabilistic for of future uncertainties. A more refined probabilistic encoding process could be useful for developing conditional uncertainties or for displaying more complicated distributional forms (Stanford Research Institute, 1976). The following shows how uncertainties for yields and exports were developed for analyzing their implications on uncertainty in prices.

Modal values for yields were chosen as those consistent with the baseline assumptions and projections (ERS, 1977). Minimum yields, below which there is virtually no probability of occurrence, were estimated subjectively by commodity analysts to represent those likely to be recorded with very poor planting, growing or harvesting conditions, given the information available at the time of the study, i.e., in early 1976. Maximum yields, above which there is virtually no probability of occurrence, were estimated similarly to represent extremely favorable weather conditions in every region of the United States. The range was to be sufficiently wide, yet not so wide as to be absurd. The triangular diagrams in Figure 1 indicate the perceived probabilities of yields falling between the minimum and the maximum values over the 1976-80 period. 1/

The probability of corn yields falling below the mode was larger than the probability of recording significantly higher yields. Thus uncertainty in corn yields was assumed to be skewed somewhat toward lower yields. Wheat yields were assumed as having very little possibility of exceeding the most likely estimates in January 1976 because of poor

Figure 1. Perceived Uncertainties in Major Crop Yields

(x- shows 1976 outcomes)



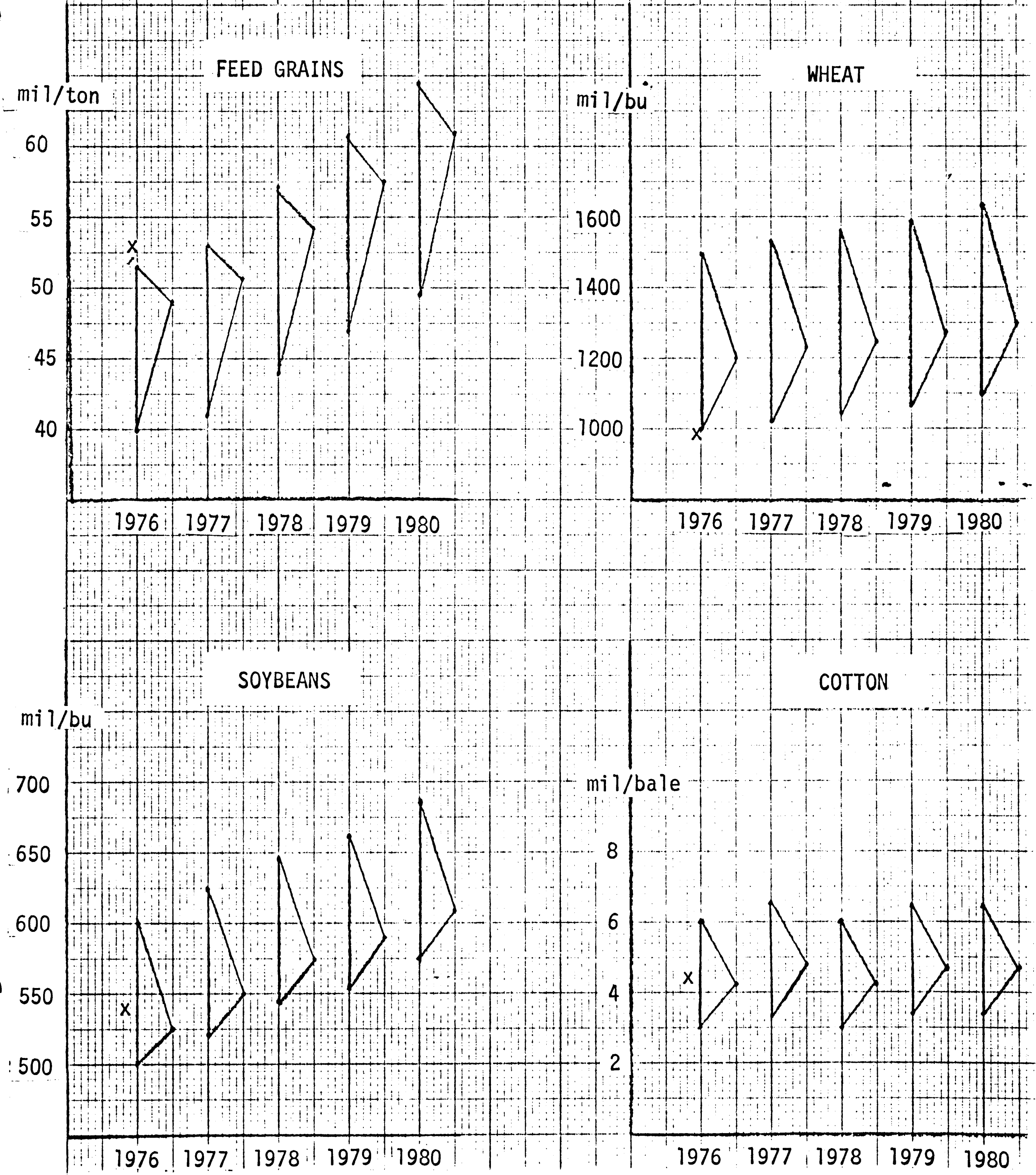
winter conditions. In the following years, uncertainties expanded. Soybeans were assumed to have an increasing maximum possible yield to 1980 because of the potential impacts of improved fertilization practices. [2/] Uncertainty in cotton yields is high at 435-525 pounds per acre and symmetric around the mode.

In comparison, statistical analysis of 1960-74 trend corn yields showed a standard error of 7.5 bushels per acre. Thus, extrapolating such numbers would indicate some potential in 1976 for reaching 114 bushels per acre as a maximum and 70 bushels per acre as a minimum, far outstripping the range of the triangular representation. Wheat has a standard error of 1.24 bushels per acre or an indicated range for 1977 of 28-36 bushels per acre, which is fairly close to the triangular range. Projecting historical deviations on soybeans of 3.3 bushels per acre would not incorporate the probable impact of applying foliant fertilizer. Statistical analysis of cotton yields suggests potential for a 414-546 pounds per acre range.[3/]

The uncertainties about exports were developed in a manner similar to those for yields (Figure 2). The end points of the range considered port and transportation capacity restraints in addition to weather variations. Cotton and wheat exports were assumed to have essentially a 60-40 chance to be above or below the modal value. The range is substantially less than the variation indicated by 1960-70 data. The wheat export standard error of 150 million bushels would indicate a normally distributed range of 750-1650 million bushels with a mode of

Figure 2. Perceived Uncertainties in Major Crop Exports

(x- shows the USDA Commodity Estimate Committee, January 1977, forecasts of 1976 outcomes)



1300 for 1980, whereas the range was adjusted to 1100-1650. The cotton export standard error of one million bales would indicate a range of 1.3-7.3 million bales with a mode of 4.8 for 1980, whereas it was shortened to 3.5-6.5 million bales. Feed grains were assumed more likely to develop exports below the mode, while soybeans were assumed to more likely develop exports above the most likely level. The range around the mode of a normal distribution from trend data for feed grain exports would be 30 million tons, whereas, it was narrowed to being about 4 million above to 8 million below the mode of 61 for 1980. Soybeans would have an export range of 260 million bushels, compared to 70 above and 30 below the mode of 610 million bushels for 1980. Thus, the formal and informal models used to develop the range generally resulted in substantially less, but skewed, uncertainty about yields and exports than did the symmetry indicated by trend analysis.

Tool of Analysis

The analytical tool used to trace through the impacts of uncertainty in yields and exports upon prices was POLYSIM, which was modified to handle randomized yields and exports. POLYSIM is a national agricultural policy simulator developed cooperatively by the Economic Research Service and Oklahoma State University (Ray and Moriak, 1976). The computerized model measures deviations from annual baseline estimates of prices, utilization, production, cash receipts, farm expenses, farm incomes, consumer expenditures and government costs due to changes in yields and exports. Seven livestock sectors are included in the model to allow impacts of changes in feed costs to be reflected in beef, hog, lamb, broiler, turkey, egg, and dairy producer decisions. A consumption sector is included such that estimates in consumers' decisions regarding their food purchases respond to changes in farm commodity prices.

The analysis used 300 randomly drawn yield and export levels from the perceived triangular uncertainties for each of the crops. Consequently, the 300 observations of yields and exports were run through the model to estimate consistent dynamic responses on harvested acres, utilization and prices. The price uncertainties are shown in Figure 3. The chart shows the modal price in each year as being the peak of the triangle. The range of prices is shown by the end point and some indication of uncertainty is represented by the shape of the triangle. Implications for government activity could be shown by locating loan rates and target prices in relation to the uncertainty in market prices.

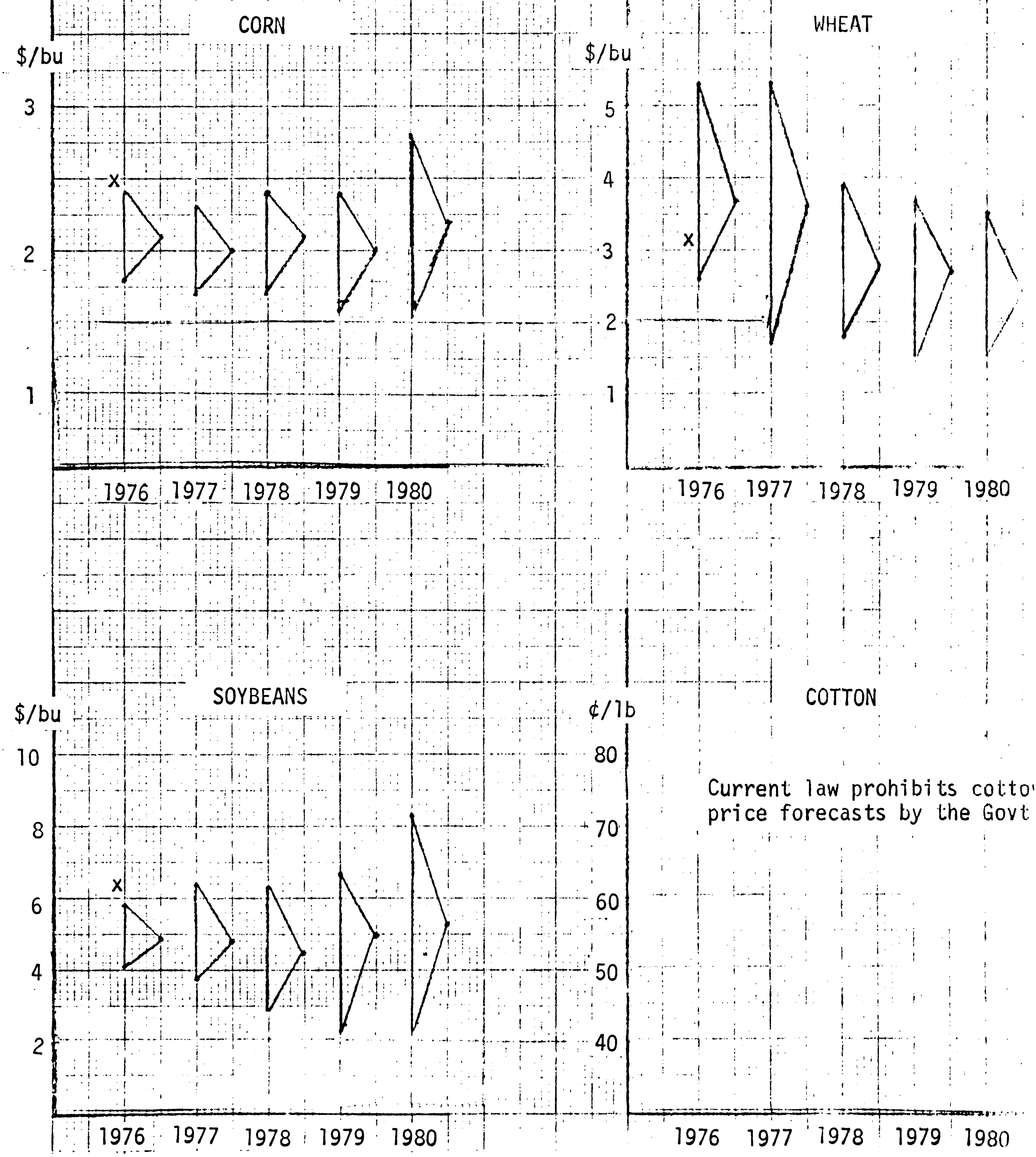
Results

Corn prices showed limited uncertainty, in January 1976, for the 1976 crop year, with a range from \$1.80 to \$2.40 per bushel with a most likely price of \$2.20. In January 1977, ERS estimated baseline corn prices at \$2.55 where the final outcomes on yields and exports were at the opposite ends of their respective ranges as perceived earlier in the season. Feed grain stocks were estimated to have virtually no potential of going below 25 million tons, but substantial potential of surpassing 45 million tons, to as much as 60 million tons by 1981.

Wheat prices, because of the huge impacts that exports and yields have on the carryover position, were highly uncertain in early 1976; from \$2.75 to \$5.25 per bushel for 1976. With unexpectedly high yield and unexpectedly low export outcomes for wheat in 1976, the ERS estimated baseline wheat price in January 1977 was \$3.10.

Figure 3. Implications for Uncertainty in Major Crop Season Average Prices

(x- shows ERS-AFPR January, 1977, baseline estimate for 1976)



Soybean prices show sharply increasing uncertainty after 1977. Production response from the application of foliant fertilizers could push prices to low levels by 1979. However, there is a low probability of that occurring. High exports and low yields could push prices above $7 per bushel by 1980. Soybean stocks could be in an extremely poor position by 1980 if we continually have high exports and low yields.

Cotton prices would show large degrees of uncertainty in every year due to the importance of the wide range on yields and exports.

Summary

Researchers are often criticized for poorly packaging their analytical results because policy officials cannot quickly grasp the important information. The reams of computer output obtainable from large systems models are useful to researchers intimately involved with the project, but will burden a staff analyst. When such systems are run stochastically, separating the decision information from the confusion inherent to the stack of numbers is a formidable task. The above approach took liberties with the precise numbers by placing a "higher value" on the broad information content of the analysis. Hopefully, this paper will stimulate other researchers to combine subjective probabilistic evaluations of future uncertainties with large systems models and then use graphical methods for communicating results.

Footnotes

1/ The January 1977 estimates for the outcomes in 1976 are also shown in order to provide a guage for performance.

2/ An Iowa State agronomist reported the potential of increasing soybean yields 30-60 percent due, at least some areas, to foliant application of nitrogen fertilizer. The skewed distribution significantly discounts the effect of the technology in the arithmetic means, but its effect on uncertainty is reflected in the widening range. Extensive field testing in 1976 showed much less promise for the foliant application.

3/ A closer look at cotton yields may suggest a bi-modal distribution with one peak around 450 pounds and another around 510 pounds per acre. This further complication is not addressed in this report.

References

Economic Research Service, Agricultural-Food Policy Review, U.S. Department of Agriculture, ERS-AFPR-1, January 1977, pp. 12-29.

Fishman, George S., Concepts and Methods in Discrete Event Digital Simulation, John Wiley & Sons, Inc., New York, 1973, pp. 201-202.

Ray, Daryll and Theodore F. Moriak, "POLYSIM: A National Agricultural Policy Simulator," Ag. Econ. Res., January 1976, pp. 1-21.

Stanford Research Institute, Decision Analysis Group, Readings in Decision Analysis, 1976.

Taylor, Bernard W. and R.M. North, "The Measurement of Economic Uncertainty in Public Water Resource Development," AJAE, November 1976, Vol. 58, No. 4, pp. 636-643.