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Report to the Chairman, Subcommittee on Government Information, Justice, and Agriculture, Committee on Government Operations, House of Representatives

April 1988

USDA'S COMMODITY PROGRAM

The Accuracy of Budget Forecasts

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Program Evaluation and
Methodology Division

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April 21, 1988

The Honorable Glenn English
Chairman, Subcommittee on Government
Information, Justice, and Agriculture
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

This report is in response to your April 17, 1986, letter requesting a review of the accuracy of the Department of Agriculture's commodity program budget forecasts and a determination, where possible, of the reasons for errors. The report presents the results of our analyses of the 1972-86 budget forecasts. It describes techniques that can be applied for measuring the accuracy of these forecasts and for isolating specific variables that can significantly account for error. It also recommends steps that the secretary of USDA might take to improve forecasts in the future. It is one of several GAO reviews of the quality of information being used for decisionmaking and it focuses on the tools federal agencies use to generate that information.

Unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 30 days from the date of the report. At that time, copies of the report will be sent to the House Committee on Government Operations, the Senate Committee on Government Affairs, and the House Committee on Agriculture. Copies will also be sent to the secretary of the Department of Agriculture and others interested in the topic.

Sincerely yours,

Eleanor Chelimsky
Director

Executive Summary

Purpose

The expenditures of the U.S. Department of Agriculture (USDA) for farm income and price support commodity programs totaled $110.7 billion during fiscal years 1972-86. However, the budget estimates that the president provided to the Congress during the same period showed that the commodity programs would cost $63.8 billion, or net underestimates of $46.9 billion. Representative Glenn English, Chairman of the Government Information, Justice, and Agricultural Subcommittee of the House Committee on Government Operations, asked GAO to review the accuracy of USDA's estimates and determine the reasons for errors.

Background

Outlays for the commodity programs are authorized by the 1985 farm bill (the Food Security Act of 1985, Public Law 99-198). The outlays must be estimated because their exact amount cannot be determined in advance. First, the secretary of USDA has discretionary authority to implement provisions that include setting some of the payment rates. Second, farmers' participation in many of the programs is voluntary. Finally, one purpose of the programs is to remove surplus production from the market, and production is affected by the weather. However, the size of the net underestimates over the years cannot be entirely attributed to these factors of unpredictability.

The commodity programs are entitlements: expenditures are based on program design and participation rather than appropriations limits. The importance of budget estimates generally is that they provide policymakers with a forecast of the outlays that the Commodity Credit Corporation makes before money is spent. They thus help the Congress monitor the programs, debate proposed revisions, and manage the deficit.

GAO concentrated its review on the process used to develop the president's budget estimates. Although some policy decisions are made on forecasts limited to specific program provisions or to budget updates the same USDA process generally provides the estimates that make up the president's budget estimate.

Results in Brief

From 1972 to 1986, most of USDA's forecasts of the commodity program outlays as set forth in the president's budget estimates contained large errors that were often underestimates. Although the percentage error rate was not higher in the more recent years, a large portion of the dollar error occurred in the last 6 years, when the budget outlays were highest. USDA has not systematically attempted to identify the source of

these errors, nor has it related them to either uncontrollable or controllable factors. Thus, USDA may not be providing the Congress with the most accurate possible budget estimates and is not evaluating its forecasting procedures with the goal of making them more accurate. In addition, USDA is not informing the Congress about the limitations of its estimates.

Principal Findings

Forecast Accuracy

USDA's budget estimates were substantially incorrect in most years. Regardless of whether an estimate was over or under the actual amount, absolute errors totaled $64.1 billion in the 1972-86 period, averaging $4.3 billion annually. Netting overestimates against underestimates for these years shows that USDA underestimated actual budget levels by an average of $3.1 billion per year. (See pages 35-41.)

Although it is true that identifying errors in forecasts that have already been made cannot guarantee that forecasts will be entirely accurate in the future, it is also the case that there is much room for improvement, especially in those areas such as the forecasting process, that are controlled by USDA. Using the measurement techniques that GAO demonstrates could notably improve both USDA's forecasting methods and its ability to pinpoint the limitations of its forecasts.

USDA's overall budget estimate for its commodity programs is developed from budget estimates for individual farm commodities. In addition to measuring the accuracy of the overall estimate, GAO reviewed those for corn, wheat, and dairy programs, because these three commodities represented 63 percent of the net outlays and 77 percent of the dollar error in the budget forecasts during fiscal years 1981-86. The largest errors were in the corn budget; USDA made absolute errors totaling $25.1 billion. On a net basis, these errors resulted in a $14.5 billion underestimate. (See pages 41-42.)

The individual commodity budgets are based on forecasts of how much the federal government will pay farmers through support programs. The input data are based on forecasts of such factors as the supply and demand of the commodity, farmer's participation, and market prices. GAO used sensitivity analysis, interviews with USDA analysts, and case studies of the budget estimating process to identify the variables that

had the greatest influence on the error in USDA's commodity budget estimates. (See pages 42-54.)

Sources of Error

Errors in forecasting the supply and demand of commodities, the individual budget for each commodity, and the overall commodity budget can result from errors in economic assumptions, program assumptions, or forecasting processes. With regard to economic assumptions, GAO was unable to determine whether errors in forecasts of such variables as inflation and gross national product caused errors in the annual budget estimates, because there is no record of how USDA analysts used these macroeconomic forecasts. However, with regard to program assumptions, GAO found that the actual implementation of a program, when it differed from its expected implementation, did contribute to forecast errors. (See pages 59-63.)

Finally, with regard to USDA's management of its forecasting processes, GAO noted problems in the evaluation of methods, data management, documentation and reporting, and underlying support structure.

Evaluation of forecasting methods. Although USDA's forecasting methods have generally been developed by highly skilled staff, little attention has been paid to reviewing and evaluating whether these methods work as intended. (See pages 64-67.)

Data management. USDA has not maintained records of input data used to make supply-and-demand forecasts. Analysts have not always used the official supply-and-demand forecasts for the budget and for policy analysis and have not documented the reasons for not using them. Analysts have not kept a systematic record of special events such as droughts, embargoes, and program changes and their effect on forecasts and actual outlays. (See pages 67-68.)

Documentation and reporting. USDA analysts generally have not documented their methods in producing forecasts. Analysts have frequently not kept copies of the computer models they used in making forecasts. Their reporting procedures deprive users of the information they need to evaluate the quality of the forecasts. USDA's reports and documents have also generally not described the confidence level or range expected in the forecasts or their error and bias. (See pages 68-69.)

Support structure. Accountability for the many disparate parts of forecasts has been spread out among so many officials that none seems quite

sure how weaknesses in the process or errors in the components affect the budget estimate as a whole. No single management organization could improve the weaknesses that they recognize. (See pages 69-70.)

USDA has not had a structured quality control program but has taken some action to correct weaknesses. In 1978, USDA established the World Agricultural Outlook Board to review and approve supply-and-demand forecasts. In another positive action, USDA has established a task force to evaluate the processes used to develop the budget estimates. (See pages 70-71.)

Recommendations

The secretary of USDA should assign to a single organization the management responsibility for coordinating the forecasting program and for establishing a structured quality control program. In order to produce more accurate, timely, and appropriate forecasts of commodity program costs, USDA should improve the management of its forecasting processes in (1) the evaluation of forecast methodology and results, (2) data management, (3) documentation and reporting, and (4) support structures for managing the processes. The secretary should also consider the recommendations made by the USDA working group established to evaluate the processes used to develop the budget estimates, many of which are in general agreement with this report. (See pages 75-76.)

Agency Comments

USDA agreed with many of GAO's findings. It emphasized in its comments on a draft of this report that it has also found the need for improving the management of its forecasting process. While agreeing with most of GAO's recommendations, USDA thought that GAO should have looked at the forecasting process in terms of all its output, including updated budget estimates, because some of the policy decisions are based on this additional information rather than on the original budget estimates. Because of the many uncertainties inherent in the forecasts, USDA pointed out that neither USDA's nor GAO's analysis can provide clear evidence that the suggested changes will improve forecast accuracy. Nevertheless, USDA believes the improvements should be made.

While GAO fully recognizes the difficulty of USDA's commodity budget forecast tasks, GAO suggests that many of USDA's comments did not address the theme of GAO's report—namely, to explore ways to improve budget estimates and the underlying forecasts or quality control process. (See appendix VII.)

Contents

Figures

Abbreviations

AAEA	American Agricultural Economics Association
AMS	Agricultural Marketing Service
ASCS	Agricultural Stabilization and Conservation Service
CBO	Congressional Budget Office
CCC	Commodity Credit Corporation
ERS	Economic Research Service
FAS	Foreign Agricultural Service
GAO	U.S. General Accounting Office
NASS	National Agricultural Statistics Service
OMB	Office of Management and Budget
USDA	U.S. Department of Agriculture
WAOB	World Agricultural Outlook Board

Chapter 1

Introduction

The expenditures of the U.S. Department of Agriculture (USDA) for commodity programs totaled $110.7 billion during fiscal years 1972-86. However, the total of the annual commodity program budget estimates that the president provided to the Congress over the same period showed the commodity programs would cost only $63.8 billion. Since USDA develops the president's budget estimate, such divergence between estimated and actual expenditures created congressional interest in determining how the estimates are developed and in exploring ways to improve both the budget estimates and the agricultural forecasts upon which those estimates are based.[1]

In this report, we respond to a request from the Chairman of the Subcommittee on Government Information, Justice, and Agriculture of the House Committee on Government Operations. In this chapter, we define forecasting and give background information on USDA's commodity programs, information on how forecasting is used in managing the commodity programs, the eight questions posed by the committee chairman, and our objectives, scope, and methodology. The chapter concludes with a summary of the organization of the remainder of the report.

Defining Forecasting

In this report, we define forecasting as a prediction of what will happen in the future given some continuation or modification of present trends. In developing this definition, we follow Wheelwright and Makridakis, who classify forecasting methodologies as quantitative, qualitative, or both, according to the extent to which a forecast can be mechanically based on historical data.[2] Quantitative techniques base a prediction of a future value on mathematical relationships of past data values, whereas qualitative techniques use more judgment in developing the prediction. These authors note that all forecasts deal with the future but that the future may be short or long. They point out that forecast error will always exist but that a common goal of managers and analysts should be to minimize it.

We emphasize this broad definition of forecasting rather than the more restrictive definition of modeling. We use "model" to refer to the mathematical representation of relationships used to make forecasts. A model may or may not require a computer.

[1]The words "estimate" and "forecast" are used interchangeably throughout this report.

[2]Steven C. Wheelwright and Spyros Makridakis, Forecasting Methods for Management (New York: John Wiley and Sons, 1973), pp. 1-5.

USDA Commodity Programs

Farm legislation in the early 1930's and amendments and modifications to it established the foundation for current farm policies and programs. The most recent update of this legislation came in the Food Security Act of 1985 (Public Law 99-198). The basic objectives of present federal farm policy have changed little since they were first formulated during the Depression of the 1930's. The objectives that relate to commodity programs are to provide farmers with a fair return on their investment, stabilize the agricultural economy, and assure consumers of an abundant supply of farm products at reasonable prices. A complex system of farm price support, farm income support, supply management, and other farm programs has been built over the years to accomplish these objectives.

USDA's Agricultural Stabilization and Conservation Service (ASCS) is responsible for program planning, budgeting, and day-to-day activities for the commodity programs. ASCS deals directly with farmers through a national network of county offices. The Commodity Credit Corporation (CCC) is the government-owned financial institution responsible for the payment and receipt of funds related to the commodity programs.

Using Forecasted Costs of the Commodity Programs

USDA uses agricultural forecasts for a variety of purposes in managing the commodity programs. Forecasts are important throughout the management cycle: program design, budget formulation, and program execution. The Congress also relies on forecasted program costs for program design, program monitoring, and budgeting decisions.

During the design or planning and programming phases, the Congress and USDA officials use forecast results to expand their knowledge of general farm conditions, forecast the cost and effect of alternative farm bill provisions, and forecast the total cost of enacted legislation.

During congressional authorization and appropriation, the Congress and the executive branch make judgments about the costs and benefits of the USDA commodity programs in relation to other programs competing for federal funds. The congressional policymakers also need budget forecasts to manage the federal deficit.

USDA analysts make extensive use of forecasts in preparing the commodity portion of the federal budget. To estimate the annual budgetary outlays associated with the commodity programs, USDA analysts must make a number of underlying forecasts of commodity production, domestic consumption, exports, and commodity program participation. USDA

makes the president's budget estimate of the commodity program outlays for the next fiscal year in November and December and submits it in January, about 9 months before the beginning of that fiscal year. USDA updates each year's budget estimate three times: a midsession review in July before the fiscal year starts, in January during the presidential budget estimate for the next year, and in the following July at the time of the next year's midsession review.

Each year, USDA officials use forecasts to consider the alternative costs and effects of the possible options that legislation leaves at the discretion of the secretary of USDA. They prepare a preliminary regulatory "impact analysis" document that outlines the expected cost differences of the various options. After the secretary's selection is announced, USDA again forecasts the cost effect of the option selected and issues a final regulatory impact statement. The forecasted costs of the secretary's actions are included in the next revision to the budget but are not individually estimated. Program managers use forecasts to consider the effect of alternative actions they can implement in managing the program. And the Congress uses forecasts on the cost of alternative programs, sometimes changing programs by amending their legislation.

Policymakers in the Congress, the administration, and each USDA organization use forecasts in each of these management processes. According to a former undersecretary of USDA, policymakers cannot escape the reality that all decisions at the policy level have a political effect that determines their willingness to use the results of forecasts.[3] Forecasted program cost is only one input to the budget process, but it is perhaps the area where the direct link from forecast to final product is the most clear.

USDA uses forecasts in formulating commodity situation-and-outlook reports. Published for public use, these reports focus on the worldwide supply-and-demand conditions for each commodity and report on recent production and market developments. They help increase the general knowledge of USDA policymakers and help establish a baseline for program decisions.

[3]Dale E. Hathaway, "The Interface Between Policymakers and Model Builders," Modeling Agriculture for Policy Analysis in the 1980s, Federal Reserve Bank symposium, Kansas City, Mo., September 1981.

The Need for the Present Report

We have a long history of involvement with forecasting and modeling issues. We summarized this history through 1978 in Models and Their Role in GAO.[4] Our work has included inventories of forecast models, evaluations of specific forecast models and models' uses, and reviews of the simulation models used by the U.S. Department of Defense. We also use forecasts developed by others, including forecasts produced through large macroeconomic models of the national economy.

Some of our studies have identified forecast limitations in various government agencies and departments. In a recent report, we noted that federal retirement model forecasts are vulnerable in several areas, including the adequacy of forecast model documentation, the frequency or recency of forecast model maintenance, and the existence of evaluative information on forecast accuracy. We reported similar conditions of the lack of documentation and validation in the DOD weapon-system acquisition programs.[5]

The concern of the House Subcommittee on Government Information, Justice, and Agriculture about the rapid escalation in the cost of the commodity program, the importance of accurate cost estimates for informed congressional oversight of the program, and our ongoing interest in the forecasting methods used in several government agencies led to the initiation of this report. The 5-year total of commodity budget outlays for fiscal years 1977 through 1981 was about $20 billion; it was about $81 billion for fiscal years 1982 through 1986. Commodity program outlays totaled about $26 billion in fiscal year 1986 alone.

Objectives, Scope, and Methodology

Our objectives were to provide information on USDA's use of forecasting to develop its commodity program budgets and to suggest improvements. The Chairman of the Subcommittee stated that answers to the following eight questions would be of interest.[6]

- What models or analysis techniques are used to develop forecasts?

[4]U.S. General Accounting Office, Models and Their Role in GAO, GAO/PAD-78-84 (Washington, D.C.: October 1978).

[5]U.S. General Accounting Office, Retirement Forecasting: Evaluation of Models Shows Need for Information on Forecast Accuracy, GAO/PEMD-87-6A (Washington, D.C.: December 1986) and DOD Simulations: Improved Assessment Procedures Would Increase the Credibility of Results, GAO/PEMD-88-3 (Washington, D.C.: December 1987).

[6]The request letter is printed in appendix I. We revised the wording of some of the questions to focus on budget forecasting, in accordance with agreements made with the Subcommittee staff.

- How are forecasts used to determine the budget request for commodit programs?
- How accurate are the commodity budget forecasts?
- Which variables contribute significantly to error in the forecasts?
- What are the methodological problems in USDA's budget forecasting techniques?
- What are the problems of coordination and communication between decisionmakers and analysts?
- To what extent does USDA have adequate quality controls for ensuring the accuracy of the forecasts?
- What promising practices might USDA adopt?

We focused our evaluation on the USDA forecasts of program costs that are used to prepare the president's budget estimate for the commodity program. We reviewed USDA's forecasting processes for program desigr program implementation, or research only to obtain descriptive inform tion on the total forecasting system. We determined this scope from th congressional letter and through consultation with the Subcommittee's staff.

One reason for focusing on budget forecasts is that the history of budg outlays can be used to assess the accuracy of the forecasts. Documenta tion is not generally available to validate the accuracy of forecasts use for design and implementation decisions or for those used for research. However, the forecasts USDA makes for the president's budget estimate provide the base from which many of the other estimates are made. Therefore, any improvements in the processes used for budgeting shou be expected to improve forecast accuracy for the other management processes as well.

We reviewed forecasting from the perspective that forecasting seeks to provide agricultural policymakers with accurate information on future costs and seeks to allow them enough lead time to use the information for decisionmaking. We did not question how policymakers use the information.

We began by reviewing the accuracy of the president's commodity budget for fiscal years 1972-86. (The accuracy measures we used and our basis for selecting them are described in appendix III. Chapter 3 focuses on budget accuracy.) We then reviewed the accuracy of the buc gets for the corn, wheat, and dairy commodity programs for fiscal year 1981-86. These programs constituted 63 percent of total commodity budget outlays for the period reviewed. Within these three commodity

groups, we studied the accuracy of each of the underlying supply-and-demand forecasts that the analysts used to develop the budget forecast. We also made a limited review of the accuracy of the budget updates and the related forecasting processes. The scope of these evaluations is described in the relevant sections.

We made a detailed analysis of the corn, wheat, and dairy budgets and underlying supply-and-demand forecasts for fiscal years 1982, 1985, and 1986. We followed the original forecasts through each of the budget updates to the actual outlays, and we attempted to identify the most likely explanation for inaccuracies. We discussed the forecasts and changes with the USDA analysts in order to identify what they believe are the reasons for inaccurate forecasts. (This analysis is in chapter 4.)

We contacted a number of experts in forecasting in general and agricultural forecasting in particular, in order to obtain criteria for the evaluation of forecasting and to identify promising practices. We describe some of the practices from the experts and from the literature.

We focused on the general processes used to develop agricultural forecasts, their accuracy, and reasons for error. We did not evaluate technical matters such as the specification of mathematical relationships used in the models. By concentrating on three commodities, we were able to review in more depth than if we had included all commodities. By emphasizing budget forecasting, we were able to find historical records that facilitated studies of accuracy.

The results of our accuracy measurements cannot be generalized beyond the forecasts used to make the president's budget estimate for the commodities and the years we reviewed. However, a major focus of our evaluation was to demonstrate techniques that USDA could use in managing and monitoring the broader range of forecasting used for program design, budget updates, and policy analysis. Although the commodity programs differ, the analysts for commodities in general work under the same management and agency guidance. The analysts generally use much of the same methodology and data bases to forecast costs for budget revisions and to make comparative analyses for design and implementation decisions. Some of our demonstrations are limited to the data available and to existing forecasting models.

During the evaluation, we discussed our objectives and the methods we used for measuring accuracy with USDA officials. After we initiated our evaluation, USDA made some improvements and formed an internal

working group of USDA staff with key responsibilities for the development of the CCC budget estimates. The improvements and the recommendations of the working group are discussed in appropriate sections of this report.

We made this review in accordance with generally accepted governme auditing standards, except that we used information on actual outlays from budget documents without cross-checking the data to audited financial records for 1972-86. We performed our field work between January 1986 and March 1987.

The Organization of This Report

Chapter 2 describes how policymakers develop and use forecasts to budget for the commodity programs and discusses the importance of budget forecasts in policymaking. Chapter 3 presents the results of ou study of commodity budget forecast accuracy and identifies the most significant variables in budget forecasting. Chapter 4 focuses on USDA's management of forecasting, methodological limitations, quality contro coordination, and communication. Chapter 5 states our recommendations for improving the accuracy and usefulness of USDA's forecasts. Appendixes contain other detailed material summarized in the report. The bibliography lists publications mentioned in the text. The report ends with a glossary.

Forecasting the USDA Commodity Budget

This chapter addresses two of our eight evaluation questions:

- What models or analysis techniques are used to develop forecasts?
- How are forecasts used to determine the budget request for commodity programs?

We also address the importance of commodity budget estimates.

General Definitions

The farm program has major provisions for corn and other feed grains and their products, wheat and its products, rice, cotton, sugar, dairy products, soybeans, wool and mohair, honey, and peanuts. The objectives of the present federal farm policy regarding these commodities are similar to objectives in previous farm bills. The commodity programs have a variety of mechanisms to support and stabilize commodity prices and producer incomes while ensuring ample supplies to consumers. The most commonly used of these are price supports, income supports, and supply management. The Food Security Act of 1985 (Public Law 99-198) spells out the provisions for each major commodity program that provides USDA with tools to accomplish its objectives. The major tools are

1. nonrecourse loans, which CCC makes to farmers who offer their crops as collateral. If after 9 to 12 months a farmer cannot sell the crop at the price level of the loan plus interest, CCC receives the crop in lieu of cash repayment. This is a price support program.

2. government purchases that support the price of milk, for example, by purchasing manufactured dairy products. This is a price support program.

3. deficiency payments, or direct subsidies available to grain and cotton farmers. The government makes these payments on the basis of the difference between the greater of the current loan price or average market price and the designated target price for each crop.[1] This is an income support program.

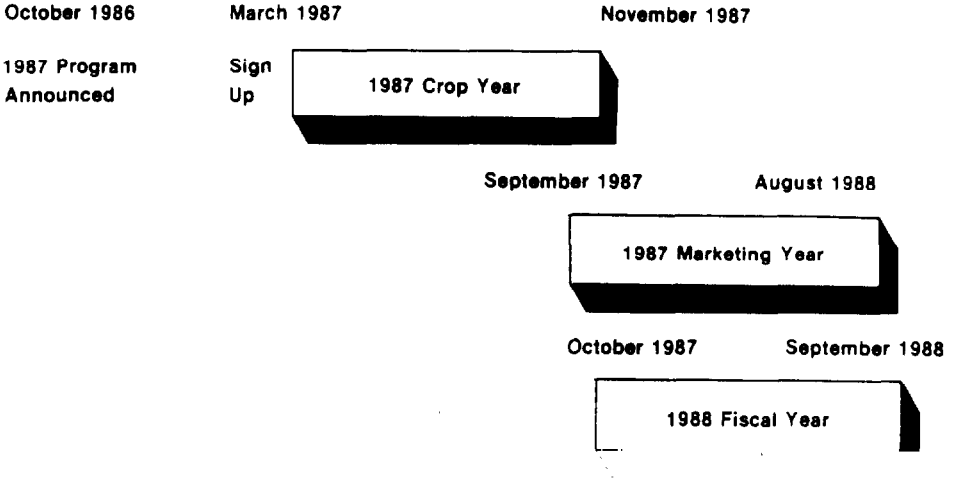
4. acreage reduction, which the USDA secretary can require of farmers who want CCC loans and deficiency payments. The secretary can also offer voluntary acreage reduction (paid diversion), so that farmers

[1]Minimum target prices first became statutory under 1973 legislation and are still effective under current legislation. Target prices are set at a level to moderate the effect of fluctuating market prices and provide farmers with a stable income.

receive cash—or, as in 1983, payments with USDA commodities, called "payment in kind." These are supply management programs.

A distinction between the crop year, the marketing year, and the fiscal year is shown in figure 2.1. The example was taken from the 1987 corn program. Dates vary for other commodities.

Figure 2.1: The 1987 Corn Program Crop Year, Marketing Year, and Fiscal Year



Each commodity's program provisions authorize payments and receipts on the basis of a marketing year specific to the commodity. CCC generally makes payments to farmers for their program entitlements related to the marketing year that begins about the time the crop is harvested. For example, much of the payments for the 1987 corn program were for provisions that CCC announced on October 26, 1986. The farmers could sign up between November 17, 1986, and March 30, 1987, and receive payments for crops they planted between March and June 1987 and harvested during October and November.

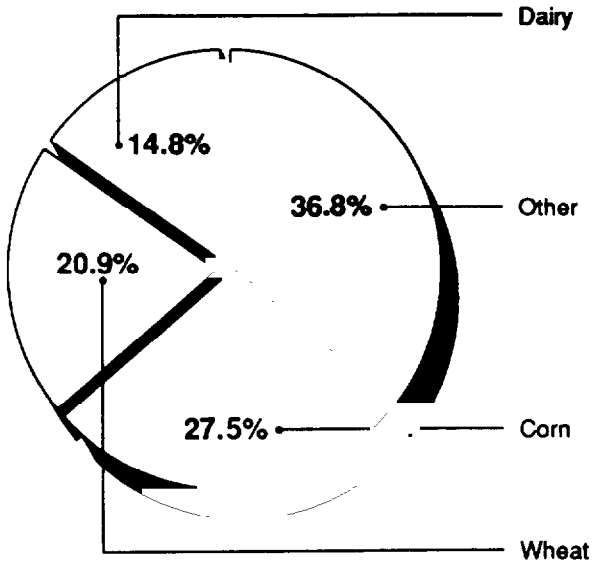
Farmers can use their harvested crop for collateral to obtain a loan from CCC. CCC also makes regular deficiency payments during the marketing year, after farmers harvest and sell their crops.

Net Outlays

Throughout this report, we deal with the CCC cost concept "net outlays," which is all cash outlays less all cash receipts. The concept measures cash flow, or the amount of money CCC spends in a given fiscal year on

the major commodity price support and income support programs.[2] Receipts come from farmers' loan repayments or when CCC sells some of the surpluses it has acquired. At the end of any given fiscal year, CCC almost always disburses more money than it has taken in. The difference is recorded as net outlays. The concept of net outlays is a measure of the public costs of supporting farm programs in a given fiscal year. From a budget perspective, net outlays reflect the drawdown of federal resources during the fiscal year, and estimated net outlays are used to estimate the deficit. The estimated net outlays are the basis for the president's budget estimate and the subsequent updates to the commodity budget during a fiscal year. Figure 2.2 shows the percentage that each commodity contributed to the total commodity program's net outlays for fiscal years 1981-86.

Figure 2.2: CCC's Fiscal Year 1981-86 Commodity Outlays



CCC makes program outlays by borrowing money from the U.S. Department of the Treasury under a $25 billion borrowing authority. CCC repays Treasury from annual appropriations, supplemental appropriations, and program receipts. The appropriations are based on "net realized losses," another cost concept that measures the public costs of supporting farm programs. Net realized losses are the amount of net

[2]Some of the information on CCC budgets is based on Geoffrey Becker, Agriculture and the Budget (Washington, D.C.: Congressional Research Service, September 16, 1986).

outlays that will never be recovered and include direct payments to farmers and losses on sales of commodities. Policymakers, however, must rely on forecasted net outlays for many decisions, because actual net outlays and net realized losses are not known until after the end of the fiscal year in which the outlays are made. (These cost concepts and their relationships are discussed in appendix IV.)

The Commodity Budget Cycle

Each January, OMB submits the president's budget estimate for the fiscal year that will start the following October. For the portion that relates to the CCC commodity programs, USDA prepares the budget estimate and the underlying forecasts during November and December. For example, during November and December 1985, USDA prepared the president's budget estimate for fiscal year 1987. USDA updates the budget estimate three times. The first update, called the midsession review budget estimate, is in July before the fiscal year starts. USDA updates its budget estimates two more times during the fiscal year when it is preparing the next year's estimates. Table 2.1 shows each successive estimate in the budget cycle.

Table 2.1: The Federal Budget Cycle

Date	Event
January	First estimate for president's fiscal year budget
July	Second estimate for midsession review of president's fiscal year budget
October	Fiscal year begins
January	Third estimate for president's fiscal year budget during the estimate for the next year's budget
July	Fourth estimate for midsession review
September	Fiscal year ends

How Forecasts Are Developed and Used in Making Budget Estimates

ASCS develops USDA's commodity budget forecast by summing 11 commodity budgets, which are developed by summing the individual forecasts for such program components as deficiency payments and loans. ASCS makes an overall budget estimate for commodity programs for the next fiscal year and for longer terms up to 5 years. In this report, we analyze only the 1-year estimates.

Analysts forecast the cost of program components with supply-and-demand variables such as production and market prices, considering the relationships of these variables to the program provisions. (Appendix II describes some of the key program provisions.) To forecast the cost of

program provisions, the analysts must forecast the level of activity, referred to as "volume estimates" (for example, the number of bushels of wheat placed under loan or the number of acres to be diverted from production) by crop year or marketing year. Volume estimates must be converted into forecasts of the outlays and receipts for the fiscal year.

Figure 2.3 shows the USDA organizations involved in preparing inputs to the CCC commodity budget. The groups under the assistant secretary for economics are involved in research and in forecasting. Those under the undersecretary for international affairs and commodity programs have input into the forecasts and are also responsible for implementing the commodity programs.

Figure 2.3: USDA Organizations Involved in Commodity Forecasting

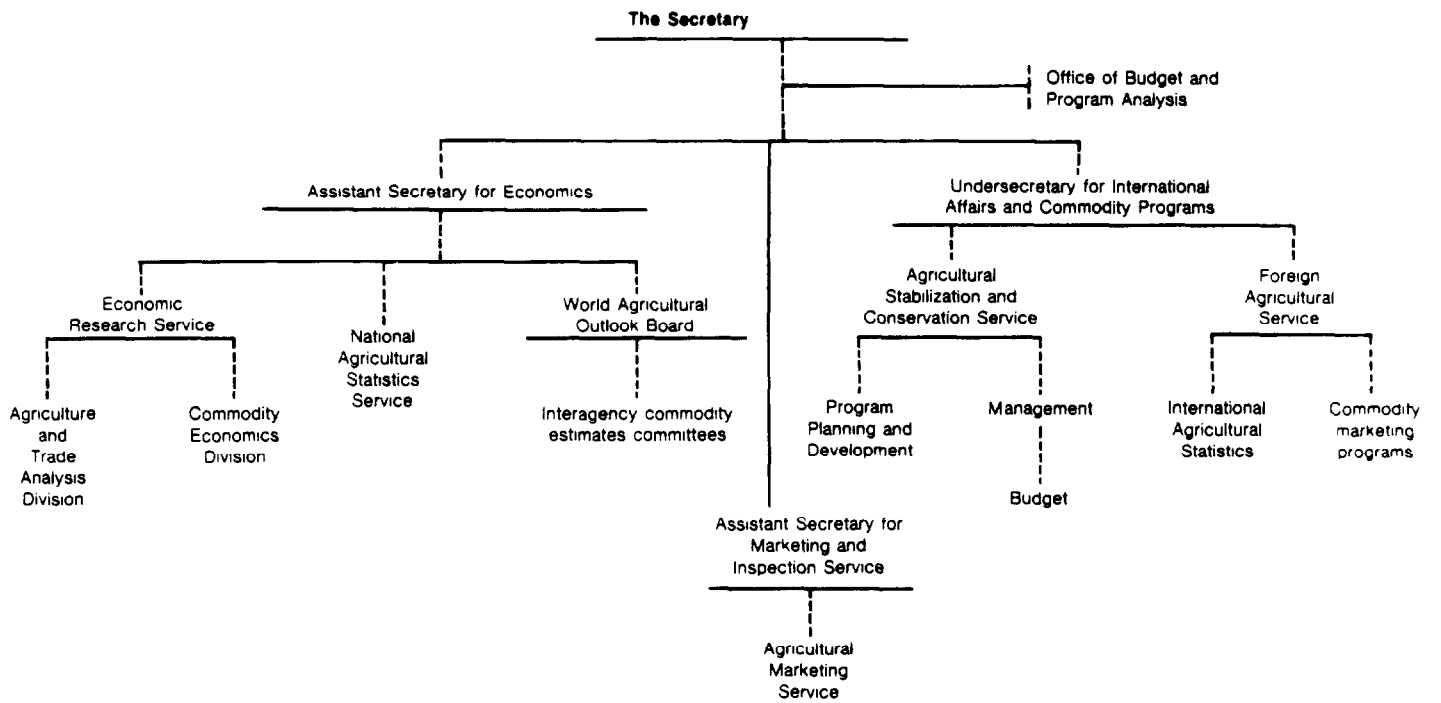
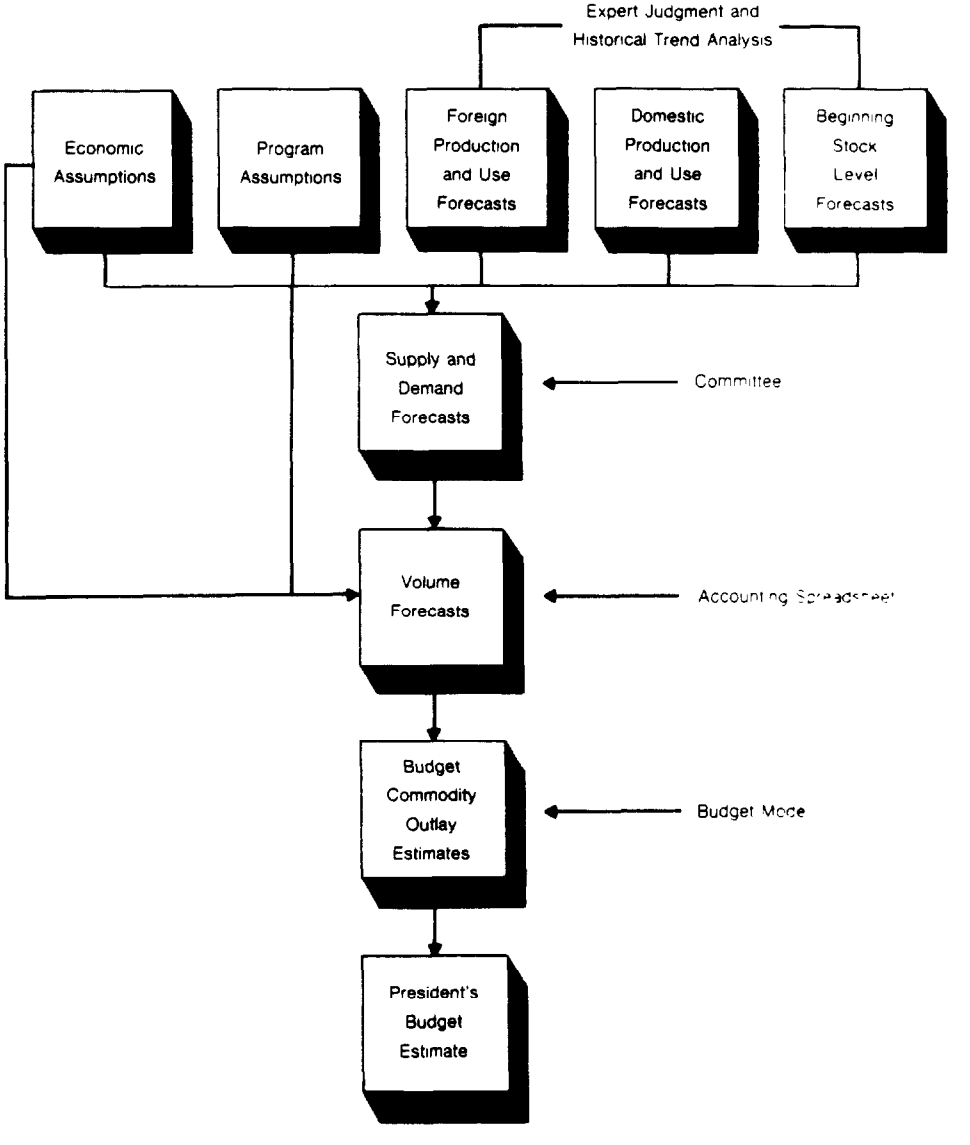


Figure 2.4 gives an overview of the use of forecasts in preparing the commodity budget. The process starts with the establishment of basic economic and program assumptions, which are provided to analysts to

use in developing the budget forecasts. The Office of Management and Budget (OMB) forecasts the macroeconomic conditions such as gross national product and inflation, and USDA policymakers provide the analysts with assumptions of how the commodity programs will be implemented considering legislative requirements and planned implementation actions by the USDA secretary. Experts from several USDA organizations help ASCS make supply-and-demand estimates.

Figure 2.4: The Commodity Budget Forecasting Process



Economic Assumptions

OMB requires that all government agencies' budget estimates be consistent with its macroeconomic forecasts of such variables as inflation, unemployment, and interest rates. USDA officials said they use OMB's macroeconomic forecasts as the official economic assumptions of the domestic economy for budget guidance, and forecast analysts said they consider these assumptions in making their forecasts. Macroeconomists from the Economic Research Service (ERS) supplement OMB's projections with forecasts about how the economy will specifically affect farmers. The forecast analysts have the economic forecasts available as they make judgments, but these forecasts have little direct application in calculations or models used for budget forecasts. Furthermore, the OMB forecasts do not cover the world economy or foreign currency exchange rates, which can affect the export portion of demand and domestic market prices.

Program Assumptions

The budget estimate is USDA's forecast of the amount of net outlays that will be made in a fiscal year for the commodity program that the administration says will be implemented. That is, the budget estimates are based on program assumptions—a commodity-by-commodity description of how the commodity programs will be implemented. The implementation of some provisions of the commodity programs is specifically set by legislation. For the implementation of many others (such as the loan rate and whether CCC will make advance deficiency payments), the secretary of USDA has wide discretionary authority, whose purpose is to allow the secretary to improve market competitiveness and reduce surplus supplies by reacting to short-term forecasts of farmers' income and commodity supply and demand.

Supply-and-Demand Estimates

Interagency commodity estimates committees make the USDA commodity supply-and-demand forecasts that are used to prepare the president's budget estimate. Supply is the total amount of production plus beginning stocks, and demand is the total consumption plus exports. Ending stock levels are the difference between supply and demand. Also included in supply-and-demand forecasts are forecasts of the market price at the producer level and component forecasts such as acreage, yield, production, imports, domestic use, and exports.

Analysts from the Economic Research Service, the Foreign Agricultural Service (FAS), the Agricultural Marketing Service (AMS), and ASCS participate in the committee process. ERS and FAS develop most of the input on foreign production and use, and ERS and ASCS develop most of the input

on domestic production and use. ASCS develops the information on beginning stock levels and farmers' participation in the commodity programs and provides other information on program provisions. The National Agricultural Statistics Service (NASS) and AMS provide current market and price data. This broad representation is meant to ensure that all viewpoints are expressed and all relevant expertise is used.

The individual analysts have the historical trend data and economic and policy assumptions. Using the expert judgments of the panelists, the committees reach a consensus on what they think the forecasts should be and report the results.

Commodity Program Volume and Cost Estimates

ASCS's commodity analysis division first estimates the degree of participation for each commodity program for each of the applicable crop years. For most commodities, the estimates are based on the extent to which the expected program provisions will benefit an individual farmer under the expected production and market conditions. The analysts rely on historical trends and use expert judgment to adjust the results. The participation rate estimated by ASCS is discussed and may be further refined in the committee meetings.

ASCS's commodity analysis division uses the economic and program assumptions, the supply-and-demand estimates, and estimates of the level of participation of farmers to develop forecasts of the activity or program volume for each commodity. The analysts also prepare program cost estimates for each commodity program by crop or marketing year and convert the information into fiscal year estimates. Most of the program outlays for a crop or marketing year are made in the next fiscal year, but some of the net outlays may be made over several years. The process is further complicated for wheat because most of the net outlays for a fiscal year are based on portions of 2 crop years.

For each commodity, ASCS's commodity analysis division uses various methods that include spreadsheets on microcomputers and manual spreadsheets to develop forecasts of the total program activity or program volume. For example, the analysts who prepare the corn and wheat volume forecasts use a microcomputer spreadsheet. The dairy program volume forecasts are not computerized, and all calculations are manual. The relationships of the supply-and-demand variables and the major program provisions also vary from commodity to commodity.

Preparation of Budget Submission

ASCS's budget division is the focal point for the final CCC commodity budget. The budget division uses a computerized budget accounting model to prepare the final budget submission. ASCS's commodity analysis division provides to the budget division estimates of net outlays for the program provisions for each commodity. The budget division adds information about the costs of storage and handling, transportation, processing and packaging, interest expenditures and rates, operating costs, program receipts, financial data on export programs, and other miscellany. The budget division enters the data provided by the commodity analysis division and the data generated by the budget division into the budget model, which then calculates the total outlays for each commodity program for each fiscal year.

The budget division prepares the CCC estimates book, which includes summaries of the outlays as well as detailed presentations of the component outlays by commodity, information on assumptions, and the underlying supply-and-demand estimates. This budget document includes the actual outlays for the 2 previous fiscal years, an estimate for the current fiscal year, and an estimate for the coming fiscal year. USDA's office of budget and program analysis incorporates information from ASCS's commodity budget into USDA's overall budget presentation. OMB then incorporates USDA's budget into the president's budget.

The process is repeated for each update to the budget estimate. In this report, we have limited our analysis to the annual estimates for the budget. USDA uses the same process to forecast the commodity program costs for 5 additional years.

The Importance of Budget Estimates

In our report entitled Managing the Cost of Government, we point out that for congressional and executive officials to make informed decisions, they need timely, accurate, and consistent financial information. Budget estimates on the costs of CCC's program activities is an important part of this information. We report that such information should be reasonably free from error and bias and faithfully represent what it purports to represent. In addition, we say that the Congress needs to know of deviations from budget estimates and their causes and effects.

Congressional and executive policymakers use forecasts of the cost of the commodity programs as input to many important decisions on the

[3]Managing the Cost of Government, GAO/AFMD-85-35 and GAO/AFMD-85-35-A (Washington, D.C., February 1985), pp. 24-28.

programs and on the budget. The Congress uses budget estimates of the costs of programs in choosing alternative designs and in managing the deficit. The administration uses budget estimates in developing an implementation plan for the discretionary activities of the USDA secretary.

The Congress has revised the legislation that authorizes the CCC-operated programs as entitlement programs numerous times, most recently in 1985. Analysts from USDA and the Congressional Budget Office (CBO) made budget estimates of the cost of the provisions throughout the legislative debate.[4] These estimates enabled policymakers to choose among competing alternative provisions and to evaluate the overall forecasted cost of the new farm bill over a 3-year period. The final design was estimated to cost about $54 billion during fiscal years 1986-88.

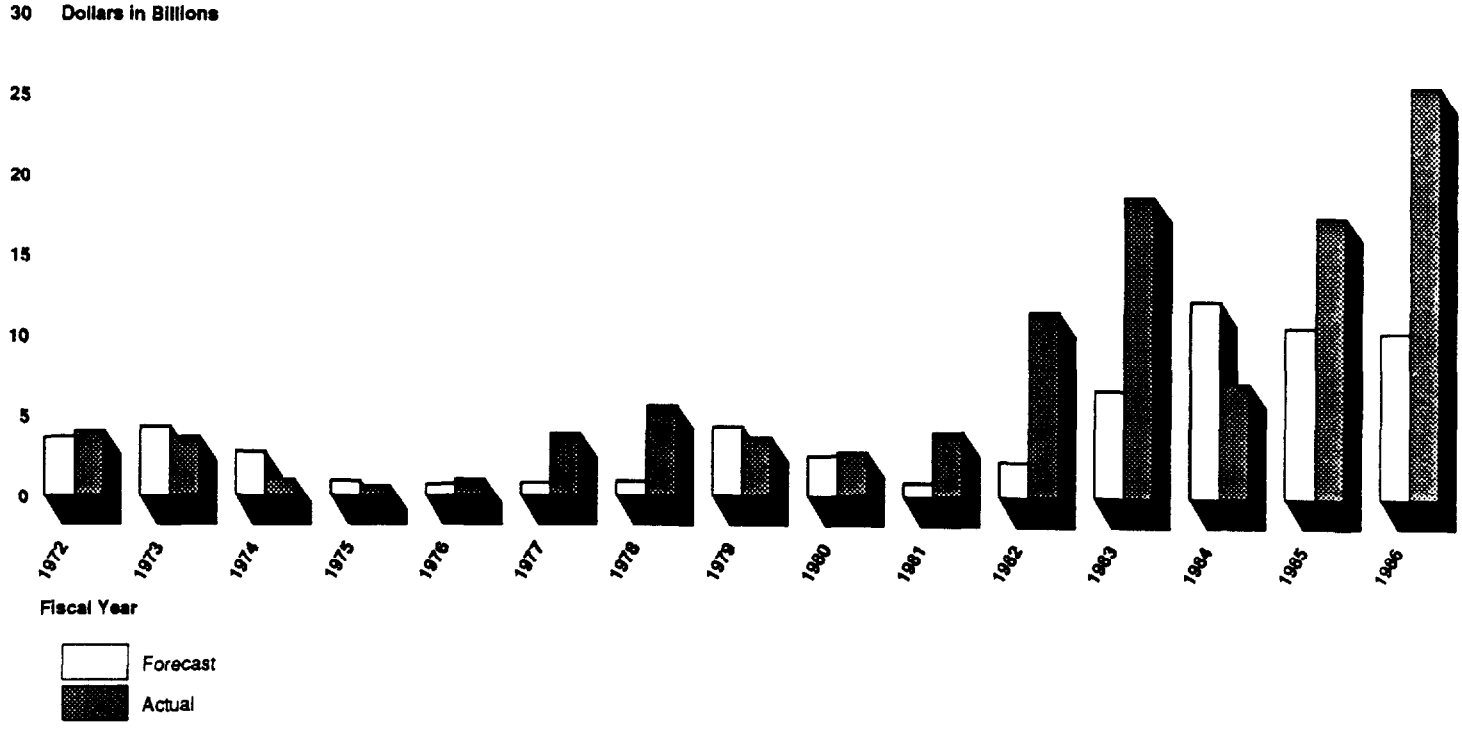
The specific design of the farm programs is dependent on implementation decisions by the secretary. The 1985 act provides the secretary with wide discretionary authority for implementing annual commodity programs, including authority over optional programs directed at improving market competitiveness and reducing surplus supplies. For example, the secretary can adjust loan rates and deficiency payment rates to achieve these goals. Analysts first provide analyses forecasting the alternative costs of the secretary's options and then, in regulatory impact statements, forecast the cost effect of the option selected. The budget estimate reflects the past and anticipated policy decisions that are made in designing the program and in implementing the discretionary provisions.

Since the commodity programs are entitlement programs, expenditures are based on program design and participation rather than on limits established by the appropriation process. The budget estimates give policymakers a forecast of the outlays that CCC will make from what it borrows from the U.S. Treasury. With timely and accurate information, the Congress can make decisions on program revisions and monitor the cost of the secretary's implementation plan. The Congress needs accurate budget estimates because it also uses estimates to manage the federal deficit.

[4]Some of the information on farm bill design is based on Geoffrey Becker's The 1985 Farm Bill: A Summary (Washington, D.C.: Congressional Research Service, August 20, 1986). USDA assembled an "ad hoc farm bill group for analysis" to provide the administration and congressional committees with cost estimates of alternative provisions and of the total farm program as designed in draft legislation.

USDA's forecasted cost of the commodity programs, as shown in the president's budget estimate, rarely comes close to net outlays. Figure 2.5 shows USDA's forecasted and actual net outlays for the commodity programs for 1972-86. It is clear that the president's budget estimate has not provided policymakers with accurate information on the cost of the commodity programs.[5]

Figure 2.5: Commodity Budget Forecasts and Actual Outlays for Fiscal Years 1972-86



Problems With Overall Budget Accuracy

Rudolph Penner, former director of CBO, wrote that it is not unusual, for several reasons, for budget plans to go awry.[6] One is that presidents inherit the preceding president's budget estimate and may modify pro-

[5]In chapter 3, we show that revised forecasts presented for midsession budget reviews and made with actual data on production, program participation, and current market conditions are more accurate.

[6]Rudolph Penner, "Forecasting Budget Totals: Why Can't We Get It Right?" The Federal Budget: Economics and Politics (San Francisco: Institute for Contemporary Studies, 1982), pp. 89-110

grams initiated before they take office. Even if no modifications are made, the programs are generally changed after the president's budget estimate is made. In addition, long-range budgets are normally based on wildly optimistic economic assumptions that show everything getting steadily better every day and that do not show the effects of business cycles. Penner states, however, that budget reliability should be improved because politicians are constantly frustrated by the misestimates: lawmakers work hard on program details to achieve certain budget goals, only to see their efforts overwhelmed by unforeseen events.

Problems in Making Accurate Commodity Budget Estimates

USDA officials have identified some of the problems specifically related to accurate forecasting. USDA's current budget officer has pointed out that where uncertainty in forecasting cost is concerned, farm program costs are in a league by themselves.[7] This, he says, is because farm program costs are "pegged" to market prices and to farm production, which in turn are influenced by world weather, the condition of the general economy, the foreign and trade policies of both the United States and other food-exporting nations, the rate of inflation, and the value of the dollar, among other variables. The USDA deputy director for budget and program analysis and the ASCS budget director agree, adding that the budget estimates depend on how many farmers choose to participate in the entitlement programs. In turn, the farmers' decisions to participate are often influenced by many of the factors above that occur after the estimates are made. In addition, recent legislative changes that allow the secretary to make portions of the payments to farmers with surplus CCC commodities instead of with cash may make it even more difficult to forecast outlays accurately.[8]

USDA officials said that the budget estimate they send to OMB is their best estimate of the cost of the commodity programs that they think will be implemented. They said that although the program may be implemented differently than assumed by USDA, the budget estimate is not a request

[7]As reported in "Farm Spending Forecasts: A Record of Failure," National Journal, March 23, 1985, 628.

[8]The secretary can make portions of deficiency payments to farmers with certificates that can be redeemed in cash or surplus CCC commodities. The secretary can make the decision to do this after the budget estimate has been made, which invalidates the assumption used to make the deficiency payment forecast. However, USDA estimates that much of or all the deficiency payment saved by issuing certificates is transferred to other payment programs because of the effect on market prices and farmers' participation that affects such programs as nonrecourse loans.

for funds for some program the president would like to see implemented. The budget estimate for an entitlement program that is set out in legislation differs in this regard from programs that can be modified or limited by the president or the Congress through the appropriation process. Once the commodity programs are announced, the program cost is dependent on such factors as participation, market prices, and crop yields and cannot be limited by appropriation.

Congressional Use of Budget Estimates

The budget process requires the Congress to be concerned about how closely actual outlays and receipts match the forecasts used in making decisions. The enactment of a new congressional budget process in 1974 required the Congress to vote on targets for actual outlays, receipts, and deficits. The requirement increased the need for accurate budget estimates to provide the Congress information on which to base the vote. The revised budget process also required the administration to make 5-year projections for long-term program costs.

Estimates of agricultural spending (net outlays) are included in the limitations of the federal budget resolution enacted each year under the separate congressional budget processes. This resolution precedes work on individual appropriation bills and sets annual spending targets for all areas of the budget. In fiscal year 1987, both houses assumed that federal spending limits could be met without having to make legislative changes to reduce the entitlements of the CCC commodity programs.

The Congress needs an accurate estimate of how much money CCC will spend during a fiscal year before the money is spent. CCC makes net outlays from a $25 billion borrowing authority that is repaid through appropriations and program receipts. The appropriations generally restore the borrowing authority for losses 2 years after they occur. The delay in reimbursement plus the increased costs of the commodity program has limited CCC's ability to make outlays within the $25 billion limit. In the years that USDA significantly underestimated the net outlays, the Congress did not have information for the annual appropriation process about how much money CCC would need to make the entitlement payments to farmers. To maintain cash flow, the Congress had to fund the outlays through numerous supplemental appropriations.

The enactment of the Balanced Budget and Emergency Deficit Control Act of 1985 (Public Law 99-177, commonly called Gramm-Rudman-Hollings) required that the federal budget deficit be reduced in specified steps to zero by fiscal year 1991. For fiscal year 1986, cuts totaling

$11.7 billion were ordered throughout the federal government on Febru ary 1, 1986, to take effect March 1. The USDA budget was cut $1.3 billio of which $0.8 billion was in the CCC commodity price support programs The law contains a number of special provisions on how to reduce CCC spending, including recognizing that CCC outlay savings may happen in later year because of the timing of CCC outlays for the 1986 crop programs and that no CCC-supported commodity or activity may be subject to a greater reduction than any other commodity or activity. To meet the reduction requirement in fiscal year 1986, USDA generally reduced each check to farmers by 4.3 percent for the 1986 crop year programs.

The aspect of Gramm-Rudman-Hollings most relevant to our report is that reduction was based on forecasted costs, not on actual outlays. Because USDA's actual program outlays were significantly greater than estimated, the 4.3-percent reduction exceeded the dollar target for reduction, but the deficit was also larger than predicted.

Summary

To make forecasts of the costs of individual provisions of the commodity programs, USDA analysts use component forecasts on economic cond tions, program implementation, supply and demand for the United States and other countries, and the participation of farmers in the commodity programs. The forecasted costs of the individual programs are then used to make an overall commodity budget estimate to inform the Congress about the expected fiscal year cost.

Policymakers need accurate forecasts of costs in order to choose alterna tives for designing the commodity programs and for making budget dec sions that allocate scarce resources to all federal programs. The administration needs accurate forecasts to decide on the implementatic strategy for the secretary's actions. But in recent years, USDA has rarel come close in estimating net outlays for the president's budget. Becaus the commodity programs are entitlement programs, program design an participation, not the appropriation process, govern expenditures. To control spending, the Congress must have accurate information in time to modify authorizing legislation. When net outlays exceed budget esti mates, more is spent on the commodity programs than planned.

The Congress also needs accurate forecasts of outlays to manage the deficit. Under Gramm-Rudman-Hollings, spending cuts to reduce the d icit are based on estimates. If outlays for any program exceed the estimated costs, the excess would increase the deficit and undermine the objectives of the Gramm-Rudman-Hollings statute.

Budget Forecast Accuracy

To find the extent to which policymakers have been receiving accurate budget forecasts and to determine the factors that cause misestimates, we asked the following questions:

- How accurate are the commodity budget forecasts?
- Which variables contribute significantly to error in the forecasts?

In this chapter, we describe the measures we used to evaluate both the USDA budget forecasts and the underlying variables USDA uses to develop the budget. We also demonstrate our evaluation techniques and present summary information on the accuracy of historical budget estimates and on the variables that contribute most to the error.

Accuracy as a Measure of Forecast Credibility

According to William Ascher, a forecast can be legitimately appraised by numerous criteria, but accuracy is the only major criterion that can both be applied to the appraisal of a large number of forecasts and used to identify factors that affect forecasts. He wrote that from the policymaker's perspective, the forecast's credibility is established by its accuracy. According to Spyros Makridakis and others, the ultimate test of any forecast is whether it can predict future events accurately.[1] Accuracy is not just an abstract criterion for appraisal, according to Eleanor Chelimsky, but is also a prerequisite for usefulness, if policymakers are expected to use the forecast for decisionmaking.[2]

Measures of accuracy can inform a forecast user about the uncertainty to be expected of the forecast. Since the accuracy of a forecast cannot be determined until the actual value is known, its historical credibility can be used to statistically develop probable ranges of forecast accuracy. Ranges are important, according to such authors as Stuart Bretschneider and Dale Bails, because users have a tendency to accept point estimates as certain when they are stated in a definitive fashion.[3]

[1]William Ascher, Forecasting: An Appraisal for Policymakers and Planners (Baltimore: Johns Hopkins University Press, 1978), pp. 4-8; Spyros Makridakis et al., The Forecasting Accuracy of Major Time-Series Methods (New York: John Wiley and Sons, 1984), p. 35.

[2]Eleanor Chelimsky, "Retrospective and Prospective Analysis: Linking Program Evaluation and Forecasting," Evaluation Review, June 1987, pp. 335-70.

[3]Stuart Bretschneider, "Forecasting: Some New Realities," Metropolitan Studies Program, Syracuse University, Syracuse, New York, December 1985, p. 3, and Dale G. Bails and Larry C. Peppers, Business Fluctuations: Forecasting Techniques and Applications (Englewood Cliffs, N.J.: Prentice-Hall, 1982), p. 126.

For these reasons, we focused on accuracy, comparing a forecast outlay with an actual outlay and determining any difference between the two: the forecast inaccuracy or error. Although an assessment of the quality of a forecasting procedure should not be based upon a single instance of error, the simple difference between the forecast and the actual value, which we call "single forecast error," can be used as a basis for summary error measures that characterize the quality of a series of forecasts. We used summary measures to describe the accuracy of the forecasting procedures USDA employed to estimate CCC's budget outlays.

The summary measures fall into three categories: (1) total error, (2) bias error, and (3) benchmark comparisons. (The measures, the computational formulas, and numerical examples are described in appendix III.) Theoretically, single forecast error has two components: a random part and a bias part. We refer to the total of these two components as "total error." Total error is measured with absolute measures.

Bias is especially interesting as an indicator of the quality of a forecasting procedure because the presence of bias makes a series of forecasts systematically high or low. It is sometimes called "offset error," because a forecasting bias raises or lowers the individual forecasts by a fixed amount. Bias can result from lack of objectivity on the part of the analysts or from errors in methodology or input data that are repeated over the series of forecasts.

We estimated the amount of bias error in USDA forecasts with net error and mean error. Each of these measures recognizes negative and positive signs of single forecast errors, and the two partially offset each other in a time series. The portion of the error that does not cancel out is called the bias. We also used occurrences of error to measure bias (number of times overestimated and underestimated). Net error and mean error should be used in combination with occurrences, because occurrence alone does not indicate the extent or magnitude of error.

The difference between total error and bias error is random error. Random error varies unsystematically from one forecast to another. However, over many forecasts, the mean of random error equals zero, because random errors tend to offset one another.

To measure total error (the full amount of each single forecast error) across a series of forecasts, we use the following measures of absolute values. If the absolute value of all forecast errors in a series is summed, we have total absolute error, or TAE. If the total absolute error is

divided by the number of forecasts, we have the mean absolute error, or MAE. Other measures we used were the mean absolute percentage error, MAPE, and the root mean squared percentage error, RMSPE.

Benchmark comparisons are quite different from total error and bias error measures in that they use alternative forecasts as a way to gauge the quality of the forecasting procedures in question. Statements such as "an error of 40 percent represents a poor forecast" are frequently used to describe forecast accuracy. However, the total error or bias error measurements by themselves are not enough to judge accuracy. What is missing is a basis for comparison. One way to evaluate forecasts is to compare them with forecasts developed with other methods or by other analysts. Thus, an error of 40 percent may not be bad if the next best forecast has an error of 50 percent. We distinguished two types of benchmark: competitive forecasts and "naive" forecasts.

We found that a number of private, "competitive" forecasters make estimates that parallel USDA's estimates of commodity supply-and-demand variables. Competitive forecasts are made for such variables as production, domestic use, exports, and ending stocks. Robert Winkler and Makridakis found that combining forecasts using a simple average or a weighted average that is based on historical accuracy is better than most individual forecasts.[4]

We demonstrate in this chapter how John Ferris combined individual forecasts made by members of the American Agricultural Economics Association (AAEA) to compare to the results of naive forecasts and to USDA forecasts. We also combined the forecasts of independent commodity market analysts who participated in a study with Futures: The Journal of Forecasting and Planning to demonstrate the technique of using a combination of forecasts as a benchmark.

Naive forecasts, those based strictly upon historical data without accounting for factors such as changes in laws, can be used as benchmarks at the budget outlay level. One form of naive forecast would be to simply draw a straight line through points representing historical outlays and make the forecast by extending the line to a future point. The simplest naive model uses the latest actual value as the forecast. Using a naive forecast as a benchmark is based on the idea that such forecasts are apt to be poor and that if more sophisticated forecasts, including

[4]Robert L. Winkler and Spyros Makridakis, "The Combination of Forecasts," Journal of the Royal Statistical Society, 146 (1983), 150-57.

those by USDA, are not substantially better, then the quality of the more complex and costly procedure is questionable. In our analysis, we produced simple naive forecasts for comparison with USDA's forecasts. USDA may find that other, more sophisticated, naive models can provide useful forecasts for comparison.

According to Ascher, meaningful comparisons of forecast accuracy require a sufficient number of forecasts.[5] In our evaluation of accuracy, we used time-series information from 1972 through 1986 for some analyses of the budget numbers. To evaluate USDA's forecasted costs for individual commodities, we concentrated on the last 6 years, because the costs of the commodity program increased substantially during this period and limited information was available to explain reasons for error prior to this period.

The chair of the World Agricultural Outlook Board reviewed our error measures and agreed that they are appropriate, adding that statistician believe a time series of about 20 years is needed for statistical reliability. We believe it is not possible to wait 20 years to evaluate the quality of forecasts in an area of this importance, since it is already clear that information is needed to improve the process. Furthermore, much of modern statistics is based on the notion of small sample properties, in which small is defined as from 3 to 30 cases. Forecast accuracy can be studied both statistically and managerially with as few as five observations. In cases in which the measurements are unduly influenced by outliers, managerial judgment can be applied in the use of the results. In addition, as data become available, this analysis can be updated to accommodate a longer time series.

The CCC budget is based on several layers of component forecasts. Some of the component forecasts are simply summed to make an overall forecast. Others consist of relationships of such factors as the program provisions, the market, and production. The values of the overall forecasts, component forecasts, and input variables to these forecasts are subject to error. The evaluation of error, however, must be made in the context of how much each variable contributes to the forecasts—the importance of the variable to the final forecast.

We based our determination of the relative importance of the individual commodity budgets and the program volumes on the dollar value of the

[5]William Ascher, p. 14.

forecast and actual values. We reviewed the significance of input variables such as supply, demand, and price forecasts by reviewing how the analysts believed the variables affected program benefits, reviewing the program provisions, and conducting sensitivity analysis. Sensitivity analysis makes percentage changes to the input of a forecast model to assess the extent to which errors in the variables may be carried over to the final forecast.

In summary, the attributes of accuracy that should be measured are

- single forecast error,
- total forecast error over a time series,
- bias error over a time series,
- accuracy relative to benchmarks, and
- the significance of input variables.

In the following sections, we demonstrate how we used the measures above for the president's CCC budget estimates. Then we demonstrate the same measures for the individual commodity budget estimates that contribute most to the error. We discuss the measures for the corn commodity budget in this chapter, and the measures for the wheat and dairy budgets are included in appendixes V and VI. We continue to disaggregate the forecasts by measuring the error for the significant input data to these individual budgets. The objective of a systematic approach is to identify the input variables that have a high total error or bias rate and that contribute significantly to the overall budget error.

The Accuracy of the Commodity Budget Forecasts

The total error in USDA's commodity budget estimates averaged $4.3 billion each year for the 15-year period from 1972 to 1986. Generally, the errors in the estimates show an underestimation bias. That is, USDA underestimated the cost of the commodity programs by an average of $3.1 billion per year.

Table 3.1 shows USDA's commodity budget forecast compared to the actual net outlays for each fiscal year 1972 to 1986. The table shows the single forecast error, the percentage error for each year, and measures of total error and bias error over the time series. Figures 3.1 and 3.2 illustrate how single forecast error and percentage error varied.

Table 3.1: USDA Commodity Budget Forecasts and Single Forecast Error 1972-86[a]

	Net outlay		Error[b]	
	Initial forecast	Actual	Single forecast	Percent[c]
Fiscal year				
1972	$3 6	$4.0	$0 4	9 0
1973	4 3	3 6	(0 7)	(21 0
1974	2 7	1 0	(1 7)	(169 9
1975	0 9	0 6	(0 4)	(62 1
1976	0 7	1 0	0 3	33 9
1977	0 8	3 8	3 0	78 2
1978	0 9	5.6	4 8	84 6
1979	4.3	3.6	(0 7)	(19 7
1980	2.5	2.7	0.2	7 6
1981	0.9	4.0	3 1	77 6
1982	2.2	11.6	9 4	81 5
1983	6.7	18.8	12 1	64 4
1984	12.3	7 2	(5 1)	(71 3
1985	10.7	17.6	6 9	39 3
1986	10.4	25.7	15 3	59 5
Total[d]	**$63.8**	**$110.7**		
Error				
Total				
Absolute (TAE)			64 1	
Mean absolute (MAE)			4 3	
Mean absolute percentage (MAPE)				58 6
Root mean squared percentage (RMSPE)				84 9
Bias[e]				
Net (NE)			46 9	
Mean (ME)			3 1	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Percent errors were computed with exact numbers.

[d]Totals may not add because of rounding

[e]Underestimated 10 of 15 years.

Figure 3.1: CCC Budget Forecast Dollar Error Fiscal Years 1972-86

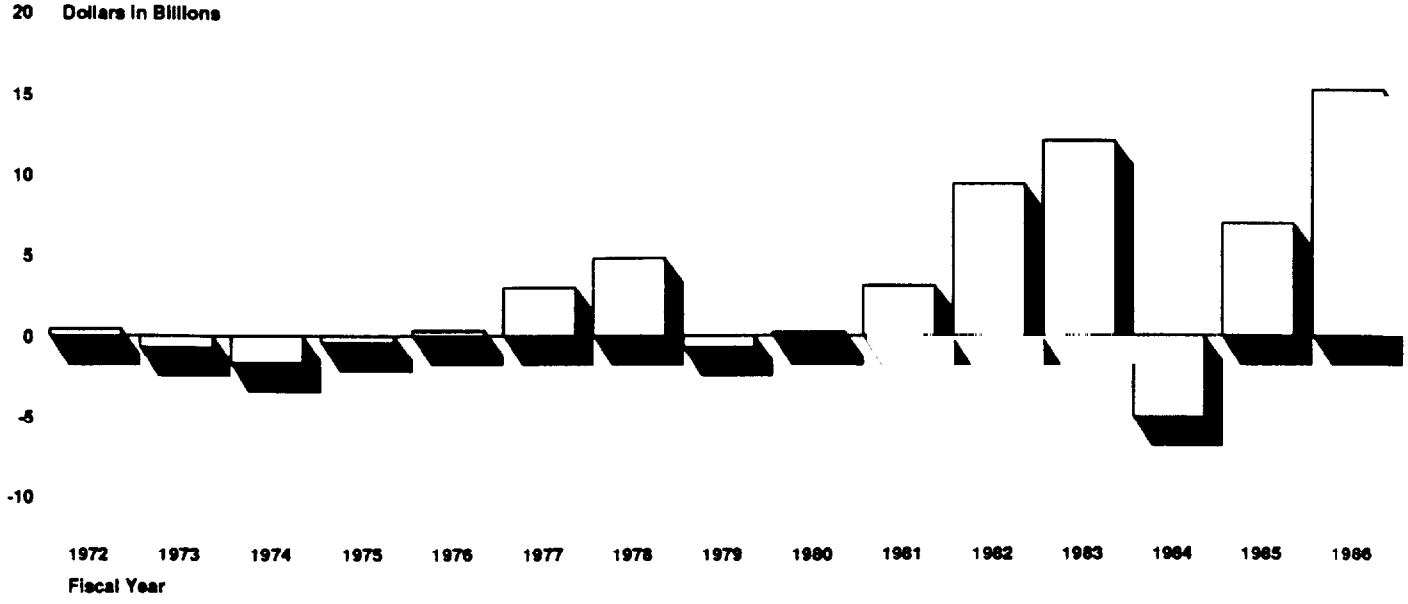
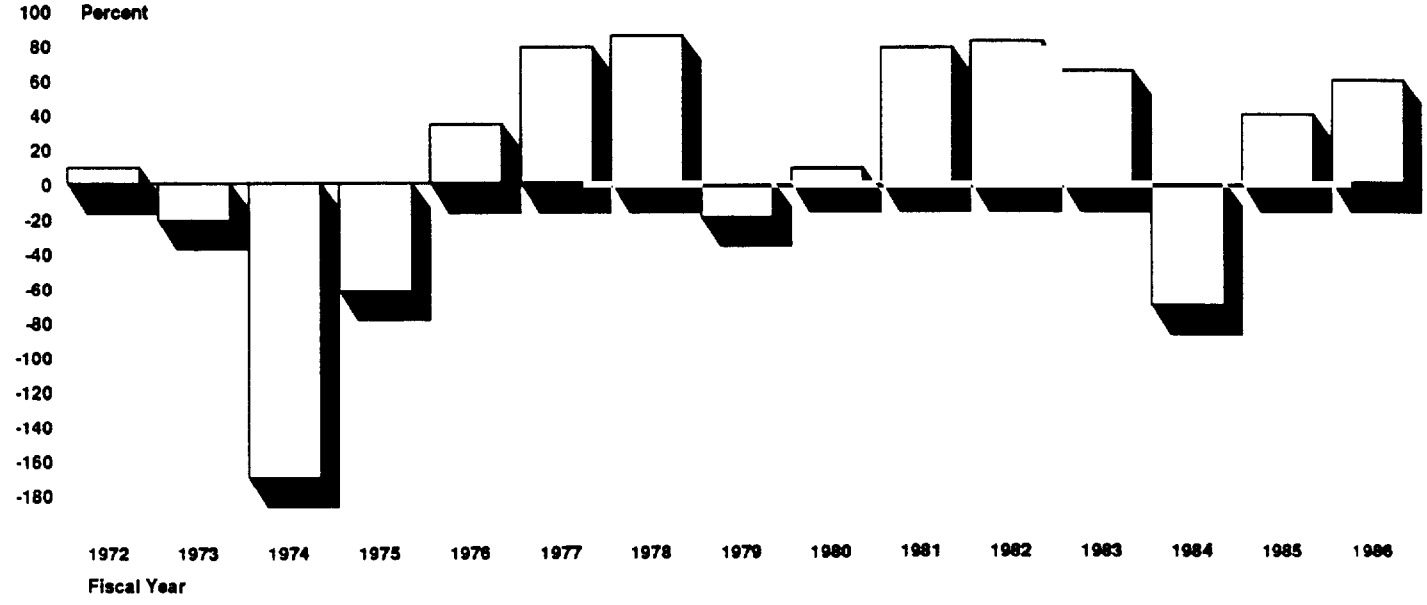


Figure 3.2: CCC Budget Forecast Percentage Error Fiscal Years 1972-86



Total Error

The total absolute error over the 15-year period was $64.1 billion. Eighty-one percent of the absolute error, $52.0 billion, occurred during the 6-year period 1981-86. USDA officials told us this 6-year period was more difficult than normal to forecast because the world economy changed dramatically, there was a drought in 1983, and USDA implemented a payment-in-kind program in 1983 that was not accounted for in the forecasts. They said a major reason the dollar value of the error increased was that total commodity program expenditures significantly increased during this period. They said the big jump in program costs was generally caused by large U.S. surpluses, weak demand, and high support prices. The surpluses occurred when good weather in most of the years resulted in high production at the same time that foreign competition reduced U.S. export markets.

To determine if the error in the USDA budget forecasting has worsened over time, we computed the mean absolute percentage error for the most recent and preceding two 5-year time periods. In table 3.2, we show the error measure over three 5-year time periods and over the entire 15-year period. This comparison indicates that USDA's commodity budget forecast accuracy was not substantially different in the last 5-year period from either of the two other 5-year periods. However, a formal statistical test showed that at the 95-percent confidence level, USDA had about the same level of forecast accuracy (in terms of MAPE) over the entire period.

Table 3.2: USDA Commodity Budget Forecast Error 1972-86[a]

Period	No. of years	Total mean absolute percentage	Bias	
			Net	Mean
1972-76	5	59.2	$(2 1)	$(0 4
1977-81	5	53.5	10 3	2
1982-86	5	63.2	38 6	7 7
1972-86	15	58.6	46 8	3

[a]Dollars are for fiscal years in billions. Positive errors are underestimates

Bias Error

USDA's commodity budget forecasts for fiscal years 1972-86 tend to show that the programs will cost less than they actually do. Over the full period, the net error associated with bias is $46.8 billion. This figure is the difference between the sum of the forecast commodity outlays over the 15 years, $63.8 billion, and the actual outlays for the same period, $110.7 billion.

Expressed as mean error, the bias for the 15-year period was $3.1 billion. That is, on the average, USDA underestimated budget outlays for commodities by $3.1 billion a year. USDA underestimated the net outlays in 10 of the 15 years. During the 6-year period 1981-86, USDA underestimated net outlays by a yearly average of $7 billion. USDA underestimated the net outlays in 5 of the 6 years; the exception occurred because a year of drought depressed agricultural production. Diminished production reduces the amount of commodities eligible for program payments and increases market prices; farmers tend to repay rather than default on their loans.

Table 3.2 also shows that the largest dollar amount of bias error was in 1982-86. USDA underestimated commodity program outlays by an average of $7.7 billion each year, causing the federal deficit to be underestimated by a similar amount. Formal statistical hypothesis testing at the 95-percent confidence level shows that USDA forecasts have been biased and, in fact, have underestimated actual costs.

The Effect of Updates on Accuracy

The accuracy of the first, second, and third updates to the budget improved. The improvement can be attributed to better input data, as actual values replaced forecasts for expenditures, program implementation strategies, farmer participation, acreage planted, and market prices. However, as shown in table 3.3, the accuracy did not significantly improve until the second president's budget estimate, in January of the fiscal year being forecasted, 1 year after the initial president's budget estimate was submitted.

Table 3.3: Accuracy of USDA Commodity Budget Updates 1981-86[a]

	President's budget estimate	First midsession review	President's second budget review	Second midsession review	Actual net outlay
Net outlay	$43.1	$47.4	$71.2	$84.1	584.8
Mean error	$41.7	$37.4	$13.6	$0.8	0
Mean absolute percentage error	65.6%	56.6%	25.9%	12.5%	0

[a]Dollars are fiscal year 1981-86 cumulative totals in billions.

Benchmark Comparisons

We believe USDA's complex budget forecasting process was not particularly successful in forecasting costs for the president's budget for fiscal years 1981-86. Our simple naive forecast, developed as a benchmark

generally contained less error and less bias than USDA's sophisticated and more intensive methods. Our benchmark forecasted next year's net outlays equal to the actual outlay figure that was available to USDA when it made the president's budget estimate. For example, when USDA forecast the fiscal year 1988 budget, it had actual outlay information for fiscal year 1986. In table 3.4, we compare the accuracy of the USDA commodity budget forecasts to the accuracy of our naive model for fiscal years 1981-86. At least three observations can be made.

Table 3.4: Comparison of USDA and Naive Model Forecasts 1981-86[a]

	USDA			Naive		
	Forecast	**Error[b]**	**Percent**	**Forecast**	**Error[b]**	**Percen**
Fiscal year						
1981	$0.9	$3.1		$3.6	$0.4	
1982	2.2	9.4		2.7	8.9	
1983	6.7	12.1		4.0	14.8	
1984	12.3	(5.1)		11.6	(4.4)	
1985	10.7	6.9		18.8	(1.2)	
1986	10.4	15.3		7.2	18.5	
Total[c]	**$43.1**	**$41.7**		**$47.8**	**$37.0**	
Error						
Total						
Absolute (TAE)		$52.0			$48.2	
Mean absolute (MAE)		8.7			8.0	
Mean absolute percentage (MAPE)			65.6			51.0
Root mean squared percentage (RMSPE)			67.9			74.3
Bias[d]						
Net (NE)		41.7			37.0	
Mean (ME)		7.0			6.2	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Totals may not add because of rounding.

[d]Net error underestimated 5 of 6 years; naive error underestimated 4 of 6 years

1. The simple naive model we used is slightly more accurate than USDA's complex system over the period 1981-86, as shown by the absolute errors. USDA forecasts had absolute errors of $52 billion, compared to absolute errors of $48.2 billion for the naive model. However, over the

longer period 1972-86, USDA budget estimates were substantially more accurate than our naive forecasts.

2. The net error shows USDA's forecasts contained a higher bias rate than the naive forecast, but both forecasts had considerable bias toward underestimation. USDA underestimated the budget outlays in 5 of the 6 years, while the naive forecast underestimated the budget outlays in 4 of the 6 years. The naive forecast's net underestimation for the 6 years was $37 billion, while the net underestimation of USDA's forecast was $41.7 billion for the same period.

3. Both the MAPE and the RMSPE are high for the naive model, which shows that the commodity budget is difficult to forecast, as USDA officials say. One reason for the large error is that actual net outlays fluctuate significantly from year to year, but naive forecasts do not take account of turning points.

In showing the naive forecast results, we are not, of course, implying that USDA could use the naive forecast to develop its budget estimates. The naive forecast does not include the kinds of assumptions or provide the level of detail that would be needed for the budget. However, a naive forecast is an inexpensive and quick way of developing an alternative forecast for benchmark comparisons of total error and bias. Benchmark forecasts, such as the naive forecasts, can be made concurrently with the normal process to ensure that differences are defensible. Benchmarks can be developed after the actual values are known in order to evaluate the validity of the forecasting process.

The Accuracy of the Corn, Wheat, and Dairy Budget Forecasts

The accuracy of the commodity budget has been a point of public interest and discussion for some time, and the large forecast errors have been reported many times by the press and others. Furthermore, policymakers in USDA have studied the misestimates and know about the general conditions that caused them. The evaluation of forecasting, however, requires more than general knowledge of the reason for misestimates. Since the commodity budget forecast is based on a number of component forecasts and each of these is developed by a variety of methods and a number of analysts, each aspect of this process influences forecast accuracy.

To evaluate the accuracy of component forecasts and the related input variables, we concentrated on the corn, wheat, and dairy components of

the USDA commodity budget. Their net outlays represent about 63 percent of the total USDA commodity program net outlays and about 77 percent of the total error in the commodity budget estimates over 1981-86. See table 3.5.

Table 3.5: USDA Budget Forecast Total Error by Commodity 1981-86[a]

Commodity	Total absolute error	Percent of total error
Corn	$25.1	48.3
Wheat	9.1	17.5
Dairy	5.8	11.1
Total	**$40.0**	**76.9**
Other	12.0	23.1
Total	**$52.0**	**100.0**

[a]Dollars are fiscal year 1981-86 cumulative totals in billions

To evaluate the three commodities, we

- assessed the total error and bias of their forecasts for fiscal years 1981-86,
- used a simple naive model as a benchmark for forecast accuracy,
- used sensitivity analysis and interviewed analysts to identify the most important variables in budget development,
- assessed the total error and bias of the significant input variables, and
- used competitive private forecasts of supply-and-demand variables as a benchmark of the relative accuracy of the significant input variables.

Corn Budget Error, Bias, and Key Variables

USDA's largest dollar errors in 1981-86 occurred in the corn budget. The large errors were biased toward underestimation. Compared to a simple naive forecast, USDA's corn budget estimates contained less total error but were more biased. The two largest component forecasts contained large error biased toward underestimation. As table 3.5 shows, $25.1 billion total absolute error in the corn commodity budget forecasts was about half the TAE for all commodities during the 6-year period.

Table 3.6 shows the corn budget errors year by year. We see that the single forecast errors were high each year, ranging from a 99-percent underestimate to a 492-percent overestimate. The average estimating error was $4.2 billion and the MAPE, which measures the error over a time series, was 154.1 percent. The corn budget estimates were biased toward underestimating the level of spending required to support the corn commodity program; estimates were below the actual outlays in 4

of the 6 years. The analysts underestimated corn program spending by an average of $2.4 billion each year.

Table 3.6: USDA Corn Budget Forecast Error 1981-86[a]

	Net outlay		Error[b]	
	Forecast	Actual	Dollars	Percent[c]
Fiscal year				
1981	$0 07	$(0 67)	$(0.73)	(110 0)
1982	0 03	4 28	4.26	99 4
1983	1 76	5.72	3.96	69 2
1984	3.66	(0 93)	(4 59)	(491 6)
1985	1.07	4.40	3.34	75.7
1986	2.28	10.52	8.25	78 4
Total[d]	**$8.86**	**$23.33**		
Error				
Total				
Absolute (TAE)			25.12	
Mean absolute (MAE)			4 19	
Mean absolute percentage (MAPE)				154 1
Root mean squared percentage (RMSPE)				107 1
Bias[e]				
Net (NE)			14.47	
Mean (ME)			2.41	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates

[c]Percent errors were computed with exact numbers

[d]Totals may not add because of rounding

[e]Underestimated 4 of 6 years.

In table 3.7, we compare USDA's corn budget estimates to a naive model. USDA's estimates exhibited a lower total error (lower absolute error) over the 6-year period but a higher bias error (higher net error). High error rates in naive forecasts indicate that the estimates are difficult to make. However, the analysis also shows that certain factors biased USDA's forecasts toward underestimation more than they biased the naive forecasts.

USDA's total absolute error for the 6-year period was $25.1 billion. In table 3.8, we show the program provisions that were the most significant contributors to the dollar error. We show that 66.4 percent of the error in the corn budget estimate was in the estimate of net lending

(amount of loans made less amount of loans repaid). This one category for the corn commodity makes up nearly one third of the total error for all CCC commodity programs ($16.7 billion of the total $52 billion error). Next was deficiency payments, with $5.24 billion. Combining the 10 other categories, the total error is $3.21 billion.

Table 3.7: Comparison of USDA and Naive Model Corn Budget Forecasts 1981-86[a]

	USDA			Naive		
	Forecast	**Error[b]**	**Percent**	**Forecast**	**Error[b]**	**Percer**
Fiscal year						
1981	$0.07	$(0.73)		$0.87	$(1.53)	
1982	0.03	4.26		1.26	3.02	
1983	1.76	3.96		(0.67)	6.39	
1984	3.66	(4.59)		4.28	(5.21)	
1985	1.07	3.34		5.72	(1.32)	
1986	2.28	8.25		(0.93)	11.46	
Total[c]	**$8.86**	**$14.47**		**$10.52**	**$12.80**	
Error						
Total						
Absolute (TAE)		$25.12			$28.93	
Mean absolute (MAE)		4.19			4.82	
Mean absolute percentage (MAPE)			154.1			184
Root mean squared percentage (RMPSE)			107.1			134
Bias[d]						
Net (NE)		14.47			12.80	
Mean (ME)		2.41			2.13	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Totals may not add because of rounding.

[d]USDA underestimated 4 of 6 years; naive underestimated 3 of 6 years.

Table 3.8: Cost Components of USDA Corn Budget Total Error 1981-86[a]

Component	**Error**	**Percer**
Net lending	$16.67	66
Deficiency payments	5.24	20
Other (10 line items)	3.21	12
Total	**$25.12**	**100.**

[a]Dollars are for fiscal years in billions.

Table 3.9 shows that over the 6-year period, USDA made total estimation errors of 81.7 percent and 343.7 percent, respectively, for the two types of program costs with the most significant errors. We also applied three bias measures (net error, mean error, and number of occurrences) to the two cost components for the 6-year period. The measures show about an $8.5 billion underestimation bias for the period, which means that USDA estimated that the spending for both cost components would be less than

Table 3.9: Total Error and Bias Error for Significant Cost Components of USDA Corn Budget 1981-86[a]

	Total			Bias		
Cost component	Total	Mean absolute	Mean absolute percentage	Net	Mean	Years costs were underestimated
Net lending	$16.67	$2.78	81.7	$5.64	$0.94	4 of 6
Deficiency payments	5.24	0.87	343.7	2.86	0.48	3 of 6

[a]Dollars are for fiscal years in billions. Positive errors are underestimates.

it actually was. The analysts underestimated net lending by an average of $0.94 billion each year and underestimated deficiency payments by an average of $0.48 billion each year. They underestimated net lending in 4 of the 6 years and deficiency payments in 3 years. The measures show that in the years that USDA underestimated its outlays for these costs, the error was greater than when it overestimated its outlays.

Key Corn Variables

According to Ascher, determining which input variables contribute the most to the error is necessary in order to allocate effort to the forecasting tasks that would make the greatest improvement in the overall forecast.[6] The first factor is the proportional contribution of each variable to each budget estimate. The second factor, less obvious but probably more important, is the magnitude of error for each variable.

Varying the input to a forecasting model to determine the relationship of the input variables to the forecast results is called "sensitivity analysis." Varying one input at a time and assessing its effect on an outcome is referred to as ceteris paribus analysis. It means literally that all other things are held constant. Another way to conduct sensitivity analysis is to vary several or all input variables jointly to determine their combined effect.[7] If the forecasting model is automated and the interconnection of

[6]Ascher, p. 201.

[7]R. S. Pindyck and D. L. Rubinfeld, Econometric Models and Economic Forecasts, 2nd ed. (New York: McGraw-Hill, 1981), chs. 12-14.

the variables is depicted with mathematical and statistical techniques, the analyst can provide policymakers with information on the effect of alternative decisions, provide forecast ranges based on uncertainties about the value of forecast variables, and identify the variables contributing the most to the budget forecast error.

To demonstrate the potential uses of the technique in the budget error resolution process, we used a USDA policy simulation model developed by the economic analysis staff under USDA's assistant secretary for economics. Sensitivity analysis without an automated model is slower and more difficult to replicate. We could not use the process ASCS uses because it is neither documented nor fully automated.

The model we used was designed to forecast budget net outlays for policy analysis purposes, not to develop the president's budget estimate. Furthermore, the analyst did not use all the same supply-and-demand estimates that ASCS used to make its budget estimates, and the model has not been independently validated to verify that it replicates the budget process. We were limited in our ability to perform sensitivity analysis, but we can demonstrate the technique.

The model we used estimated the budgetary effect of crop year 1986. The largest outlays occurred in fiscal year 1987, but some outlays will not be made until fiscal years 1988 and 1989. The model provides estimates of budgetary effect in fiscal years 1987-89. It can be used to determine which components of supply and demand contributed the most to the error in net outlays and in individual program costs. Using actual error rates, we found some of the effects of the errors.

- A 10.41-percent underestimate in crop year 1986 total supply resulted in a $1.75 billion underestimate of net outlays in fiscal year 1987 and a $3.69 billion underestimate for 1987-89. Errors in forecasting beginning stocks had the largest effect on net outlays ($1.66 billion underestimate for 1 year and $2.64 billion underestimate for 3 years). Production had the second largest effect ($0.54 billion underestimate in fiscal year 1987 and $0.84 billion underestimate in fiscal years 1987-89).
- An 8.62-percent overestimate in crop year 1986 total demand resulted in a $0.91 billion underestimate of net outlays in fiscal year 1987 and a $1.79 billion underestimate over 1987-89. A 34-percent overestimate of exports had the largest effect on net outlays ($0.86 billion underestimate in fiscal year 1987 and $1.4 billion underestimate in 1987-89).

Although the model we used depicts the relationship of the variables to each other, the effect of individual errors on outlays cannot be added together. For example, the effect of the error in forecasting beginning stocks plus the effect of the error in forecasting production exceeds the error for total demand. Such individual analysis, however, provides information on which variables contribute the most to the error in forecasting net outlays. Furthermore, analysts with program knowledge and automation can conduct the analysis by varying multiple input variables.

Although we could not use the ASCS process, we did analyze the errors in the supply-and-demand data that ASCS used to support the budget estimates. Our analysis shows that there were large total errors and bias errors in several of the critical variables. In table 3.10, we show the error and bias measures for the supply-and-demand variables. We have grouped the variables by level. For example, the first group contains the summary variables, in that total supply less total demand equals ending stocks. The second grouping includes components of supply and demand that are used to compute total supply or total demand. We include our analysis of variables used to forecast component supply and demand variables, which we refer to as "input variables."

Table 3.10: Total and Bias Error in USDA Corn Supply-and-Demand Variables 1981-86[a]

		Bias[c]		
Variable	Error	Net	Mean	Occurrences in 6 years
Summary				
Total supply	8,058	(1,082)	(180)	Overestimate 3
Total demand	3,135	(2,897)	(483)	Overestimate 5
Ending stocks	8,201	1,815	303	Overestimate 3
Input				
Beginning stocks	2,046	1,292	215	Underestimate 5
Production	6,797	(2,387)	(398)	Overestimate 3
Imports	13	13	2	Underestimate 3
Domestic use	1,452	(284)	(47)	Overestimate 4
Exports	2,613	(2,613)	(436)	Overestimate 6

[a]In millions of bushels. Positive errors are underestimates.

For the component supply-and-demand variables, the largest total error (measured by absolute error) was in the estimates of production, and the largest bias error (measured by net error) was in the estimates of exports. The forecasting error for production at first appears relatively random, because the analysts overestimated production in 3 years and

underestimated it in the 3 other years. But considering the net and mean error measures, the errors were larger in years analysts overestimated than in years they underestimated.[8]

USDA's estimates of corn exports were the most consistently biased (as measured by net error and occurrences of error) of all the significant corn variables. The analysts each year estimated that more bushels of corn would be exported than actually were exported. Unrealized export expectations generally resulted in larger domestic surpluses, which tended to depress prices and resulted in larger participation in USDA support programs.

Typically, when production estimates exhibit an overestimation bias, budget outlays are also overestimated, because actual surpluses are less than forecasted. Thus, the bias toward overestimating production appears at first to be inconsistent with the large budget underestimate described in previous sections. However, the bias measures were unduly influenced by the untypical events of 1984 resulting from a severe drought in 1983 and large acreage reductions from farmers' participation in the 1983 payment-in-kind program. In table 3.11, we present a comparison of the mean error including and excluding 1984.

Table 3.11: Mean Error in USDA Corn Supply-and-Demand Variables 1981-86[a]

Variable	1981-86	1981-86 excluding 1984
Summary		
Total supply	(180)	557
Total demand	(483)	(39
Ending stocks	303	948
Input		
Beginning stocks	215	334
Production	(398)	22
Imports	2	2
Domestic use	(47)	60
Exports	(436)	(45

[a]In millions of bushels. Positive errors are underestimates.

Except for 1984, the analysts generally underestimated total supply and overestimated total demand, resulting in a fairly large underestimate of ending stocks. The underestimate of supply was composed of underestimates of both beginning stocks and underestimates of production. The

[8]USDA stated that poor weather reduces yields more than the good weather raises yields. USDA estimates average weather conditions each year, which it says contributes to the overestimates being greater than the underestimates.

overestimate of demand comes from a large overestimate of exports, which was partially offset by a smaller underestimate of domestic use. An underestimate of ending stocks generally means a larger surplus on the market than the analysts projected, which ultimately results in lower market prices than they expected. With large surpluses, farmers are more likely to participate in loan programs, more likely to default on previous loans, and receive higher deficiency payments, all increasing program outlays. For corn, the variables contributing significantly to error in the net outlay forecasts are production, exports, and beginning stocks. The errors in beginning stock forecasts generally stem from the errors in forecasting components of supply and demand for the prior year, since beginning stocks (also the prior year's ending stocks) are the residual of supply and demand. Imports had virtually no effect, and domestic consumption had a fairly small effect on the error in net outlays.

Input Variables

Several input variables affect the accuracy of the supply-and-demand component variables. In table 3.12, we show the error and bias measures for harvested acres and harvested yields, which are the input variables for the production estimate. We also show the error rate for seasonal average price, which is both an input variable and an output of the interactions of supply and demand.

Table 3.12: Error and Bias Measures for USDA Corn Input Variables 1981-83 Plus 1985-86[a]

Error	Harvested acres[b]	Harvested yield[c]	Seasonal average price[d]
Total			
Absolute (TAE)	7,855	34 3	$2 11
Mean absolute (MAE)	1,571	6 9	$0 42
Mean absolute percentage (MAPE)	2.13%	6.32%	6 29%
Bias[e]			
Net (NE)	717	3 5	$(0 89)
Mean (ME)	143	2 7	$(0 18)
Years costs were overestimated	3	2	3

[a]Data are for fiscal years.

[b]Thousands of acres.

[c]Bushels per acre.

[d]Dollars per bushel

[e]Positive errors are underestimates

The data cover fiscal years 1981-86 (excluding 1984) and show that the analysts came very close in estimating the number of acres of corn that would be harvested (0.14 million acres average underestimate in 69.9 million acres actual average), but they underestimated the average yield per acre. An average underestimate of 2.7 bushels yield per acre when multiplied by an average of about 70 million acres resulted in a large average underestimate of corn production. In addition, the analysts overestimated seasonal average price by $0.18 per bushel.

Benchmarking Corn Supply-and-Demand Variables

Benchmarks for supply and demand variables can be based on the comparative performance of similar forecasts made by other forecasters or on naive models. Benchmarks can be developed when forecasts are prepared as verification that differences between the benchmark forecast and the forecast made by the normal process are defensible. Benchmarks can also be developed after the actual values are known for a check on validity. In the following paragraphs, we demonstrate how USDA's forecasts can be compared to both competitive forecasts and forecasts made with naive models. To validate USDA's process, the comparison should be based on several years' historical data for both USDA's and competitive forecasts. However, analysts can also compare their current forecasts to forecasts of competitive forecasters or to forecasts made with naive models, in order to increase their confidence in the reasonableness of their forecast.

To demonstrate the technique of comparing USDA forecast performance to competitive private forecast performance, we used data or comparisons from published documents. The forecasts of the private analysts are combined by statistical techniques to make comparison forecasts.[9] The USDA data in the comparisons are supply-and-demand forecasts from USDA's monthly World Agricultural Supply and Demand Estimates, which USDA uses for budget updates. Comparison of the performance of private forecasters to USDA's supply-and-demand forecasts used for the presidential budget estimates have not routinely been made, because USDA does not provide these forecasts to the public and USDA does not make such comparisons.

Our comparison of USDA forecasts to benchmark forecasts based on private forecasts of corn supply-and-demand variables shows that both USDA and private analysts have difficulty forecasting key supply-and-

[9]Combinations of forecasts are generally more accurate than individual forecasts. According to Winkler and Makridakis, pp. 150-57.

demand variables. There were no general trends indicating that private analysts consistently make more accurate forecasts than USDA analysts. However, benchmarks based on the combined forecasts of private forecasters were more accurate than the forecasts made by USDA's panel.

Our first source of private forecast benchmarks for USDA supply-and-demand variable forecasts is based on forecasts made by members of the American Agricultural Economics Association. The individual analysts' input was combined by John Ferris, whose study considered four variables (production, exports, ending stocks, and price) that correspond to some of the most important variables used to make the ASCS budget forecasts. The comparison of the accuracy of these forecasts to USDA's is shown in table 3.13. USDA's forecast of each of the corn variables was less accurate than the combined forecasts of private forecasters or the naive model or both.

Table 3.13: Comparison of USDA, AAEA, and Naive Model Corn Forecast Error[a]

Variable	USDA	AAEA	Naive model[b]
Ending stocks	53.9	51.7[c]	70 7
Production	15.0	14.8[c]	29 1
Exports	17.1	14.9	13 2[c]

[a]Root mean squared percentage error. The comparison period is 8 years (crop years 1978-85)

[b]Uses previous year's actual as the forecast for forthcoming year.

Source: Adapted from John Ferris, "Evaluation of Forecasts from the Annual AAEA Outlook Survey presented at the annual meeting of the American Agricultural Economics Association, Reno, Nevada July 1986.

Our second source of private forecasts for benchmarking was Futures: The Journal of Forecasting and Planning, which compared USDA forecasts to those of independent commodity market analysts for the 1985-86 crop year. The private analysts made their forecasts just before USDA published its supply and demand forecasts in World Agricultural Supply and Demand Estimates. We averaged the Futures analysts individual forecasts for May 1985.

Table 3.14 shows that the combined forecasts of the private forecasters were superior for five of the eight variables, including those our sensitivity analysis has shown to be the most significant variables (production and ending stocks). However, the degree to which the private forecasters achieved less error was relatively small.

Table 3.14: Comparison of USDA and Futures Corn Forecast Error[a]

Variable	USDA	Futures[b]
Supply and demand		
Total supply	13.9%	13.2
Total demand	(9.3)	(10.2
Ending stocks	51.5	50.9
Components of supply and demand		
Beginning stocks	28.3	24.7
Production	11.2	11.0
Domestic demand	(2.5)	(0.9
Exports	(38.8)	(50.6

[a]Error is percent of actual. The comparison period is 1 year. Positive errors are underestimates.
[b]"How USDA 'Challengers' Did in Wheat," Futures, September 1986, p. 78.
[c]The more accurate of the two forecasts.

Both the AAEA survey and the Futures study show that USDA and private analysts have difficulty in forecasting the supply-and-demand variables considered here. No general trends indicate that private analysts make more-accurate forecasts than the USDA analysts. However, for several variables, a combined forecast of private analysts was more accurate than the forecast made by USDA.

Recapitulation

The largest errors in the USDA budget estimates occurred in the corn budget. In fact, the corn budget estimates contained about $25.1 billion, or about half, the total error in the USDA commodity budget estimates in fiscal years 1981-86.

The corn budget estimates were biased toward underestimating the level of spending required to support the corn commodity program. The analysts underestimated corn program spending by an average of $2.4 billion each year. The estimates were below the actual outlays in 4 of the 6 years. USDA's corn budget estimates contained less total error but had more bias than a simple naive forecast used as a benchmark.

Most of the forecasts of the cost of significant individual program provisions were in error and were biased toward underestimation. About 66 percent of the error in the corn budget estimate was contained in the estimate of net lending outlays. This one category for the corn commodity made up about one third of the total error for all CCC commodity programs ($16.7 billion of the fiscal year 1981-86 total error, which was $52 billion). The second largest error was in deficiency payments, where the total error was $5.2 billion. The total error of the 10 other categories

amounts to $3.2 billion. The supply-and-demand variables that contributed significantly to the errors in the corn budget forecasts were the interagency commodity estimates committees' estimates of production, exports, and ending stock levels.

USDA's estimates of corn exports were the most consistently biased of the important corn variables. The analysts each year estimated that more bushels of corn would be exported than actually were exported. Except for 1984, the analysts generally underestimated supply and overestimated demand, producing a fairly large underestimate of ending stocks. This means that there was generally a larger surplus on the market than the analysts projected and that market prices were lower than they expected. With lower market prices, farmers are more likely to participate in loan programs, more likely to default on previous loans, and receive higher deficiency payments. All these factors increase program outlays.

Analysis of two benchmark forecasts produced by private forecasters shows that combined private forecasts had lower errors than USDA in several key variables such as production and ending stocks. However, USDA did better than the combined forecasts of private analysts on three of eight variables. The private analysts and USDA analysts both had difficulty forecasting the key corn supply-and-demand variables.

Wheat Budget Error, Bias, and Key Variables

The wheat budget and its components make up the second largest component of error in the USDA commodity budget forecasts, accounting for about $9.05 billion, or 18 percent, of the total error during fiscal years 1981-86.[10] USDA's wheat budget estimates and several of its important components were biased toward underestimation. USDA's forecasts exhibited larger total error and bias error than did a simple naive model. The analysts underestimated the wheat budget net outlays in each of the 6 years by an average of $1.51 billion each year.

USDA's wheat budget estimates, in comparison to a naive forecast, had a higher total error, a higher bias error, and higher percentage errors over the 6-year period.

[10]We analyzed the error and bias in USDA's wheat budget estimates and underlying forecasts, using the same measures and methodology presented in our discussion of the corn budget estimates. The analysis here is presented in more detail in appendix V.

The largest total errors in the wheat budget estimates occurred in the estimates of net lending ($4.74 billion) and deficiency payments ($3.01 billion). USDA generally forecast that spending would be less than it actually was.

Most of the important supply-and-demand variables that influenced the wheat budget and component cost estimates were the interagency commodity estimates committees' estimates of production and exports, and the residual components of beginning and ending stocks. The underestimate of total supply was composed about equally of underestimates of production and beginning stocks. Errors in the estimates of exports and domestic consumption tended to offset each other, resulting in fairly accurate estimates of total demand. In effect, errors in production and export forecasts were especially important. However, errors in the wheat variable forecasts are smaller and more nearly random than errors in the corn variables.

Private forecasters responding to a Futures survey made better forecasts, on the average, than USDA did for the wheat production and domestic use variables for 1986. In general, the USDA analysts achieved lower error percentages than the combined private forecasters on price, exports, and ending stocks.

Using the AAEA survey that compared USDA forecasts to a naive model and to private forecasts for crop years 1978-85, USDA forecasts for three key wheat variables (production, exports, and price) were more accurate than either the AAEA survey or the naive model. The AAEA forecasters, on the average, made a better forecast of ending stocks.

Dairy Budget Error, Bias, and Key Variables

The dairy budget and its components make up the third largest component of error in the USDA commodity budget forecasts, accounting for $5.8 billion, or about 11 percent, of the total error during fiscal years 1981-86.[11] USDA's dairy budget estimate and its most important component exhibited a bias toward underestimation. In addition, the USDA dairy budget estimate had higher total error and more bias than a simple naive model. Over the 6-year period, the analysts not only underestimated dairy program spending by an average of almost $1 billion each year; they also underestimated the budget in each of the 6 years

[11]The detailed analysis of the dairy budget total error, total bias, and key variables is [illegible] Appendix VI

The naive estimate had a slightly lower total error and a considerably lower bias error than the USDA forecast over the 6-year period. This indicates that the USDA error was more biased than the naive forecast. However, both forecasts contained large errors.

The most important component in the dairy budget estimate is the estimate of spending required to support the purchase of surplus dairy products, which is the primary mechanism of the dairy program. This component makes up about 93 percent of the error in the dairy budget estimates. The analysts underestimated dairy purchase spending each year. The average underestimate was $0.91 billion.

The key variables for estimating dairy net outlays and component costs are the interagency commodity estimates committees' estimates of production and commercial use, which determine CCC net removals. The errors in forecasts of production and net removals were biased toward underestimation. Most of the error in the estimate of net removals can be directly traced to the error in dairy production. The forecasts of commercial use had a slight bias toward overestimation. This tended to compound the error of underestimating production. Considerably more dairy products were produced than expected while somewhat less of the dairy products were used commercially than expected. This resulted in the government's purchasing a larger surplus.

Summary

In answering the questions for this chapter, we used measurements on single forecast error, total error, bias error, sensitivity analysis, and comparison to benchmark forecasts.

USDA's commodity budget estimates included large errors in most years. The total error averages more than $4 billion each year for the 15-year period 1972-86. The total absolute error over the 15-year period was $64.1 billion. Eighty-one percent of the absolute error, $52 billion, occurred during the 6-year period 1981-86, when net outlays also significantly increased.

In general, the errors in the estimates were underestimates. USDA usually estimated that the commodity programs would cost considerably less ($3.1 billion on the average) than they actually cost. USDA underestimated the net outlays in 10 of the 15 years. The estimates made for the president's budget did not generally provide reliable information to policymakers in either the administration or the Congress about the true costs of the CCC commodity programs.

The corn, wheat, and dairy components represent 63 percent of the total USDA commodity budget outlays and 77 percent of the error in the commodity budget estimates over the period 1981-86.

The largest errors in USDA's budget estimating occurred in the corn budget. The estimates contained large errors and were generally biased toward underestimation. The important forecasts of component costs were in error and were biased toward underestimation. Over the 6-year period, the analysts underestimated corn program spending by an average of $2.4 billion each year. The absolute error for the 6-year period was $25.1 billion. USDA's corn budget estimates contained less total error but were more biased than a simple naive forecast used as a benchmark. About 66 percent of the error in the corn budget estimate is contained in the estimate of net lending. This one category for one commodity makes up nearly one third of the total error for all CCC commodity programs ($16.7 billion of the total $52 billion error).

The wheat budget and its components make up the second largest component of error in the USDA commodity budget forecasts, accounting for about 18 percent of the absolute dollar error during fiscal years 1981-86. The budget estimates and several of the important components were biased toward underestimation.

Over the 6-year period, the analysts underestimated wheat program spending by an average of $1.51 billion each year. The absolute dollar error for the 6-year period was $9.05 billion. USDA's forecasts exhibited larger error and bias than did a simple naive model. As with the corn budget, the largest single component of error in the wheat budget is contained in the estimate of net lending.

The dairy budget makes up the third largest component of error in the USDA commodity budget forecasts, accounting for about 11 percent of the absolute dollar error during fiscal years 1981-86. The budget estimates and the most important component were biased toward underestimation.

Over the 6-year period, the analysts underestimated dairy program spending by an average of almost $1 billion each year. They underestimated the budget in each of the 6 years. USDA's dairy budget estimate had a higher error and more bias than a simple naive model. The most important contributor to error—about 93 percent of the error—in the dairy budget estimate was the estimate of spending required to support the purchase of surplus dairy products.

Table 3.15 recapitulates the total error and bias error measures for the corn, wheat, and dairy commodities and the total CCC commodity budget over fiscal years 1981-86. The data show that the largest dollar errors and percentage errors were in the corn budget estimates.

Table 3.15: Error and Bias Measures by USDA Commodity 1981-86[a]

Error	Corn	Wheat	Dairy	All
Total				
Absolute (TAE)	$25 1	$9 1	$5 8	$52 0
Mean absolute (MAE)	$4 2	$1.5	$1 0	$8 7
Mean absolute percentage (MAPE)	154.1%	50.7%	48 5%	65 6%
Root mean squared percentage (RMSPE)	107 1%	58 3%	53 3%	67 9%
Bias				
Net (NE)	$14 5	$9.1	$5 8	$41 7
Mean (ME)	$2.4	$1.5	$1 0	$7 0
Years costs were underestimated	4	6	6	5

[a]Dollars are for fiscal years in billions. Positive errors are underestimates.

[b]Number of years underestimated

For corn and wheat, the variables contributing most significantly to the errors in the forecasts were production, exports, and the residual beginning and ending stocks; for dairy, the most important variables were production, commercial use, and the residual net removals.

USDA's estimates of corn exports were the most consistently biased of the important corn variables. Each year, the analysts estimated that more bushels of corn would be exported than actually were exported. Except for 1984 data, the analysts generally underestimated production and overestimated exports and, therefore, produced a fairly large underestimate of ending stocks. This means that there was generally a larger surplus on the market than the analysts projected and lower market prices than they expected. With lower market prices, farmers are more likely to participate in loan programs, default on previous loans, and receive higher deficiency payments, all of which increase program outlays. Similar but smaller and less biased errors were made in the wheat variable estimates. In addition, USDA analysts generally underestimated dairy production and overestimated the commercial use of dairy products, which resulted in an underestimate of the amount of dairy products the government purchased to support dairy prices.

Our analysis of two benchmark forecasts produced by private forecasters showed that USDA and private analysts had difficulty forecasting the key corn and wheat supply-and-demand variables. In addition, both groups had more difficulty forecasting corn than wheat. No general trends indicated that private analysts made more accurate forecasts than the USDA analysts. There were, however, several variables for which a combined forecast of private analysts was more accurate than the forecast made by USDA, particularly for corn. The analysis demonstrates that USDA could use private forecasts to develop benchmarks for comparison.

Managing the Forecasting Process

The USDA commodity budget forecasting process requires that the contributions of a great number of analysts and officials be coordinated and that many components be integrated with one another. The process also spans several organizations within USDA and depends on specific individuals and groups that have program responsibility and on other individuals and agencies whose responsibilities are primarily technical or involve research. And although each part of the process is based on relatively straightforward analysis, the great number of components being forecast, contributors to the process, and variables that affect accuracy all make commodity budget forecasting a complex undertaking. Thus, it is important that the management of the forecasting process be based on sound practices. The three questions for this chapter are

- What are the methodological problems in USDA's budget forecasting techniques?
- What are the problems in coordination and communication between decisionmakers and analysts?
- To what extent does USDA have adequate quality controls for ensuring the accuracy of forecasts?

Management Practices

Research has found the following to be important in managing a forecasting process.[1]

Evaluation of forecast methodology. The appropriateness of USDA's forecast methodology can be determined in two ways. One is to verify that the methods accurately reflect the relationships of the provisions of the commodity programs to such factors as farmers' participation, market prices, and supply and demand. The other is to evaluate the forecast results by measuring historical accuracy and by comparing them to results from other methods.

Data management. An evaluation of data management determines whether the input data used for forecasting are accurate and whether

[1]U.S. General Accounting Office, Guidelines for Model Evaluation, GAO/PAD-79-17 (Washington, D.C.: 1979); S. I. Gass, Computer Model Documentation: A Review and an Approach (Washington, D.C.: U.S. Government Printing Office, 1979); William Ascher, Forecasting: An Appraisal for Policy-makers and Planners (Baltimore: Johns Hopkins University Press, 1978); J. Scott Armstrong, Long-Range Forecasting: From Crystal Ball to Computer, 2nd ed. (New York: John Wiley and Sons, 1985); Stuart Bretschneider, "Forecasting: Some New Realities," Metropolitan Studies Program, Syracuse University, New York, December 1985; Office of Management and Budget, Statistical Policy Directive on Compilation, Release, and Evaluation of Principal Federal Economic Indicators (Washington, D.C., 1985).

there are stored records of forecasts, special events or actions, and their effects on the historical data.

Documentation and reporting. The adequacy of forecast documentation and reporting is assessed by checking to see if the documentation on methodology supports the user's needs. The forecasting process should be documented so that the results can be replicated for evaluation. The forecast results should disclose the assumptions and limitations of the methodology, and they should contain measures of uncertainty or ranges to explain the expected accuracy.

Support structure. Forecast support structures are necessary so that responsible officials can adequately manage the forecast design, data, documentation, and evaluation functions.

In the following sections, we comment on USDA's use of these forecasting practices. We did not systematically evaluate all aspects of USDA's processes. For example, we did not verify that its forecast methods accurately reflect actual conditions.

When OMB and CBO make general evaluations of budget accuracy, they group the causes for misestimates into three assumption categories:

1. economic. Budget estimates may prove inaccurate if the economic assumptions they are based on are not borne out.

2. program. Unanticipated actions by the Congress or an agency can change a program and invalidate the assumptions the forecast was based on.

3. technical. Some differences between forecasted and actual amounts are the result of imprecise forecasting methods or difficulty in predicting the effect of weather on production, how farmers will react to program changes, and so on.

We used these categories because they apply logically to the USDA budget process and can generally be compared to USDA's forecasting methods and areas of responsibility for putting the budget together.

The Uncertain Effect of Economic Assumptions

It is not clear to what extent errors in OMB's forecasts of the U.S. economy affect USDA's annual budget estimate for the commodity programs. Some USDA officials we talked to said that misestimates of macroeconomic variables are a major contributor to the errors in commodity budget estimates, but others believe the misestimates have only a minor effect. After reviewing several macroeconomic forecasts (including those made by OMB and CBO) for the 6 years ending 1985, we concluded that OMB's economic forecasts over this period, while not the most accurate, were not significantly worse than alternatives available.[2] But since the macroeconomic forecasts are not a direct input to forecast computations, we could not evaluate the extent to which USDA analysts properly considered OMB's economic forecasts in making the component forecasts of the commodity budget estimate.

We found that USDA had not performed any evaluation to determine the extent to which economic assumptions account for the misestimates in the commodity budget estimates. If USDA had followed the practices we described above, the analysts would have created a documented procedure for using economic projections, stored OMB's forecasts and the actual values for evaluation, and evaluated the extent to which error in the economic forecasts caused the errors in the budget estimates.

When we asked ERS about the effect of errors in economic assumptions on USDA's annual budget estimates, ERS did a study, which it completed in November 1986, that shows macroeconomic forecast errors are not likely to be more than a minor contributor to error in the president's budget estimate.

In summary, USDA does not routinely conduct evaluations to show the extent to which errors in OMB's macroeconomic forecasts are causing USDA to misestimate its commodity budget. Although the domestic and foreign economies are closely linked to the farm economy and to the cost of the commodity programs, errors in economic forecasts have little effect on the annual budget estimates, according to limited evaluation by USDA. Determining the effect that changes in the economy have on the cost of the commodity programs is a necessary component of error resolution, yet the lack of documented forecasting methods and of stored data make it difficult to evaluate these relationships.

[2]U.S. General Accounting Office, "Budget Reductions for FY 86," 51 Fed. Reg. 2847 (1986).

Program Changes That Cause Forecast Error

The analysts who estimate the net outlays for the budget assume that policymakers will implement the programs as they are described in the program assumptions. According to Ascher, assumptions represent a forecaster's basic outlook on how to develop a specific forecasted trend and are a major determinant of forecast accuracy.[3]

The budget is based on at least three types of program assumptions, an USDA's assistant secretary for economics, undersecretary for international affairs and commodity programs, and OMB review and approve them:

1. A few implementation strategies are set by legislation.

2. Some discretionary provisions, such as loan rates, are announced before the budget estimate is made.

3. The secretary has discretionary authority for some provisions whose use the secretary might not announce before the president's budget estimate is prepared. For example, in most years the secretary can make portions of the deficiency payments when a farmer signs up for the program instead of when the crop is harvested. If payments are thus made outlays are made in an earlier fiscal year.

Some significant errors we identified in chapter 3 resulted because the programs were implemented differently than described in the program assumptions provided to the analysts. USDA had not determined the extent to which variances between the program assumptions and actual program implementation accounted for errors in the budget estimates. However, we identified the following examples by tracing some of the errors to the program changes. We made an analysis of fiscal years 1982, 1985, and 1986 to develop information on causes for error. We relied on interviews with analysts and their working documents for these years.

Corn. In fiscal years 1985 and 1986, USDA management instructed the analysts to base the budget estimates on the assumption that advance deficiency payments would not be made. After the budget estimates were published, the secretary announced that deficiency payments would be made in advance. This excluded portions of the deficiency payments from the president's budget estimate for both years. ASCS underestimated deficiency payments by $2.0 billion in 1985. The program

[3]Ascher, p. 199.

change was the direct cause of $1.2 billion of the error. In 1986, $1.3 billion of the $1.9 billion deficiency payment underestimate occurred because USDA management decided to advance deficiency payments after the budget estimate was made.

Wheat. Two program changes contributed to errors in ASCS's wheat outlay estimates. USDA underestimated wheat outlays by $2.2 billion in fiscal year 1985. The budget estimate for fiscal year 1985 includes outlays for parts of wheat marketing years 1984 and 1985. After USDA published the initial budget estimate, the Congress and USDA changed the wheat program to make it more attractive to farmers. The increased benefits resulted in higher-than-anticipated program participation for both marketing years. As a result, USDA underestimated the fiscal year 1985 loan program outlays by $0.9 billion and underestimated diversion payments by $0.7 billion. USDA also advanced wheat deficiency payments after basing the 1985 and 1986 budgets on the assumption that payments would not be advanced. This resulted in a $1.4 billion underestimate in deficiency payments.

Dairy. The 1985 farm bill added two outlay items (the "whole herd buy out" and the purchase of red meat) to the 1986 dairy budget. Because the farm bill was not passed until December 1985, these items could not have been estimated when USDA made the first forecast for the president's budget in January 1985. The analysts added these line items to the budget updates in January 1986. These program changes added $0.7 billion to the 1986 dairy program outlays.

We did not include fiscal year 1983 in our review of forecast accuracy in chapter 3, because the program was so dramatically different then from other years that we did not believe we could relate the events to errors. However, implementation of the payment-in-kind program is another example of the program's being implemented differently than assumed for the president's budget estimate. The secretary administratively implemented a payment-in-kind program in January 1983 to reduce production and stock surpluses and increase farmers' net cash incomes.

USDA estimated for the president's budget that the commodity programs would cost $6.7 billion for fiscal year 1983, but actual outlays were $18.8 billion. USDA contends that without the payment-in-kind program, which paid farmers with grain instead of cash, outlays would have been higher. We reported in September 1985 that USDA used about $9.1 billion

in CCC-owned commodities in lieu of cash to make payments to farmers. Because the secretary's implementation of the program so radically changed the commodity program, we recommended that the Congress consider limiting the secretary's authority to initiate programs such as the payment-in-kind program without specific congressional approval.

In summary, significant portions of the error can be associated with changes made to a program after the president's budget estimate was submitted. For example, we identified $6.2 billion in misestimates (excluding 1983) that resulted from program changes by the secretary or the Congress. However, USDA has not routinely evaluated the extent to which such changes affected budget forecast errors.

If USDA followed recommended forecasting principles, it would have a stored record of assumptions and implementation strategies, and it would be able to evaluate the extent to which variances account for errors in the budget estimates. However, it does not have such a data base and does not routinely make such evaluations. USDA maintains a record of some of the program assumptions in the CCC estimates book, which documents the assumptions about the current crop year but does not show the assumptions for future crop years. We had to obtain some of the information from analysts and their working documents.

Forecasting experts also recommend providing policymakers with a range of forecasts, depending on how a program is implemented. USDA officials said they do not provide this information to the Congress for budget estimates because the congressional policymakers are interested only in a "best estimate" of the cost.

USDA does estimate the alternative cost of some program provisions for which the secretary has discretion and provides the information in regulatory impact statements. But these analyses generally show only the expected cost differences among the options, without showing the total cost of the provision.

[4]U.S. General Accounting Office, 1983 Payment-in-Kind Program Overview: Its Design, Impact, and Cost, GAO/RCED-85-89 (Washington, D.C.: September 25, 1985).

Weaknesses in the Management of Forecasting Processes

Forecast analysts use methods ranging from expert judgment to computer analysis that reflects the mathematical relationships of the variables to one another. USDA's major forecasting processes for budget preparation are supply-and-demand estimates, program volume and cost estimates, and the budget estimates for individual commodities and the overall commodity budget. These processes are under the World Agricultural Outlook Board, ASCS commodity analysis division, and the USDA and ASCS budget divisions, respectively.

The commodity analysis staff provide the budget staff with forecasted net outlays for each program provision for each commodity. Since this represents the majority of the forecast outlays, we did not review the method that the budget staff used to put the results into budget format.

We recognize that when many different factors such as weather, farmers' participation, and domestic and world economic conditions have a bearing on the trend being forecasted, forecast accuracy becomes problematic. However, Ascher points to the plausible connections between accuracy and the characteristics of a forecasting technique or of forecasters and their behavior.[5] We believe that when forecast errors exceeding benchmark levels are isolated, and component forecasts that include bias are systematically identified, evaluators can associate the forecast errors with specific methodologies or individual forecasters. As a result, management knows where to allocate resources to try to improve accuracy.

We generally did not question the type of forecast methodology USDA analysts and officials chose to use. However, according to Bretschneider, after a methodology is chosen, good practices should be followed to ensure that the results are timely, accurate, and appropriate at a minimum cost.[6]

Evaluation of Forecast Methodology and Results

Supply and Demand

According to a 1978 memo establishing the interagency commodity estimates committees, the chair of WAOB is charged with reviewing and

[5]Ascher, p. 8

[6]Bretschneider, p. 15

approving the estimates and supporting analyses from participating agencies in order to develop official USDA estimates for program planning, budgeting, and evaluating present or proposed programs. In practice, however, the chair only reviews and approves forecasts published in the World Agricultural Supply and Demand Estimates report. These published short-term estimates, which cover the current crop or marketing year, are used by farmers and private industry to make plans, including decisions on whether to participate in the federal commodity programs for the coming crop year. The published estimates are not available when ASCS prepares the president's budget in November and December. However, ASCS generally uses the approved estimates for budget updates.

Forecast methodologies similar to the committees' forecast methodology are described in the literature as a panel or round-table process. Levin found that a panel process using several experts can arrive at a better forecast than can one person.[7] In this regard, USDA's organizations have placed priority on assigning to the committees highly qualified analysts with the necessary program knowledge.

Levin found that unless a panel is properly structured, the forecasts may not be as accurate and unbiased as possible. In other research, Ascher found that forecast accuracy is affected by the goals and objectives of the forecaster's institutional base and training.[8] In chapter 3, we showed that some forecasts made by USDA committees have higher total error and bias error than those of private forecasters. For example, USDA's total error rates for forecasts of corn production and ending stocks are higher than those of competitive forecasts, and the committees overestimated corn exports in 6 of the last 6 years.

We compared the committee process to the research by the forecasting experts we cited above and identified the following weaknesses with the forecast methodology that the committees use to forecast supply-and demand variables.

1. No validation of forecast methods. Neither the interagency commodity estimates committee nor WAOB systematically or formally compare their forecasts to benchmarks. Benchmarks could include consensus forecasts of private analysts or naive models.

[7]Richard L. Levin et al., Quantitative Approaches to Management (New York: McGraw-Hill 1982).

[8]Ascher, pp. 12-13.

2. Methods may contribute to bias error. Forecasts made by panels are sometimes influenced by such factors as persuasion by the member with the greatest supposed authority or loudest voice, reluctance to abandon previous positions, and the "bandwagon" effect. The interagency process does not preclude one member from biasing the forecasts, and some forecasters have an institutional bias because they represent groups responsible for program implementation.

3. Minimal error resolution process. WAOB has started making accuracy studies of its published forecasts used for budget updates, but it does not relate the occurrence of excessive error and bias to aspects of the forecasting process or to individual forecasters in order to improve the process. The committees have not systematically reviewed the accuracy of the supply-and-demand estimates made for the president's budget estimates.

Program Volume and Cost Estimates

The forecast methodology that the commodity analysis division uses to estimate program volume and net outlays relies on the expertise of the individual analysts. Their forecasts depend on accurate inputs of program assumptions and supply-and-demand forecasts, but having accurate input data does not ensure that an estimate of net outlays will be accurate, if the interactions of the variables are not properly specified in the forecast methodology. The commodity analysis division has not followed some of the practices recommended by forecast experts.

1. There is no standard methodology. Each commodity analysis division analyst who prepares forecasts of program volume and program cost for a commodity develops and maintains an individual forecast methodology. The agency relies on the professional expertise of the analysts to ensure that the forecast methodology is appropriate and correct.

2. Automation is limited. The extent to which these processes are automated varied with the commodity. The analysts for corn and wheat have automated portions of their forecasting process on a microcomputer, but the models cannot be run without the judgments of the analysts. The dairy analyst does not use a computer model.

3. Methodologies are insufficiently validated. The analysts told us they verify and validate the model to their satisfaction, but the forecast methodologies are not subjected to outside review.

4. Sensitivity analysis is not used to identify the variables contributing the most to the errors. Although the analysts are frequently aware of the most important variables, they told us that they do not use sensitivity analysis to systematically identify the variables that should receive the greatest scrutiny during estimation.

5. No formal use of benchmarks is made. The analysts said they compare their forecast results to other methods when possible, but there is no record of their comparisons. The analysts do not construct naive models to compare to their forecasts.

6. No systematic error resolution process has been developed. The analysts told us they do general evaluations to determine why forecasts are inaccurate when managers request such studies and to provide input to the budget reconciliation studies, but there is no systematic comparison of the forecasts to actual values.

In summary, the commodity analysis division methodology uses the expertise of forecast analysts who have a good understanding of the commodity programs, and the division has initiated efforts toward automation. But without validated procedures and the use of an automated model, it is impossible to determine the extent to which budget errors were caused by the errors in supply-and-demand forecasts, in program assumptions, or in the forecast method. Furthermore, it is difficult to conduct sensitivity analysis with historical error rates.

Evaluation of Data Management

Data associated with a forecasting process include the input data, the forecast results, and information explaining historical events or actions that describe input data or that influenced prior forecasts. The major weakness of forecasting, according to Bretschneider, is that the world sometimes changes in unexpected ways.[9] Special events directly influence the development and use of forecasting data, but often no adequate records are maintained. Bretschneider proposes standards for data management to ensure that the lessons of history are available. Along this line, Bretschneider recommends that the analyst and agency store and maintain forecasts, as one would store and maintain data, and maintain records of special events or actions, including estimates of their effects on the historical data maintained for use in building a forecasting

[9]Bretschneider, p. 17.

model.[10] However, recommended forecasting processes have not been followed, as shown in the following examples.

1. There is no record of input data. Committee analysts consider program assumptions, economic assumptions, yield trends, and other pertinent data in developing their input for the committee meetings. We could not review either the process they used in developing input or the input data, because the committees do not document its members' input. Therefore, the analysts are not accountable for their individual forecasts and it is not possible to relate errors to input data.

2. There is no record of special events. Neither the committees nor the commodity analysis division documents the extraordinary events that affect the input data or the forecast results. An events register could describe the effects of droughts, program changes, or political events such as embargoes. In our error resolution analysis, we could rely only on what the analysts remembered. With analyst turnover, the ability to reconstruct these events and use them to improve future forecasts is lost.

3. There are only limited records of historical forecasts. The committees do not publish or maintain a record of the supply-and-demand forecasts they make for the president's budget. The only record of these forecasts is the CCC estimates book, maintained by the ASCS budget division. We could not trace these estimates to the committees process.

4. There is inconsistent use of input data. The ASCS analysts generally use the World Agricultural Supply and Demand Estimates for budget revisions. However, we compared the supply-and-demand estimates used in making the midsession budget update to its estimates for crop years 1980-86 and found frequent instances in which the analysts did not use the official forecasts. There was no record documenting the reasons for this.

Evaluation of Documentation and Reporting

The fact that individual components of the forecast methodology do not meet best practices in documentation can mean that systematic evaluation is precluded, replicating the process is difficult, and knowledge is lost when employees leave. If the forecast results do not disclose

[10] A method for developing an events register is discussed by W. L. Gorr, "Use of Special [illegible] in Government Information Systems," Public Administration Review, 46 (November [illegible]

assumptions and limitations and show measures of uncertainty, the data have limited value for users in their decisionmaking.

1. The methodology the committees use is not documented.

2. The commodity analysis division's methods are not documented. Neither the input data and judgments nor the forecast methodology were documented for prior years' forecasts for the three commodities. Furthermore, the corn and wheat analysts have not saved copies of the computer models used in prior years.

3. The committees do not develop forecast ranges based on historical accuracy for supply-and-demand to inform users of the limitations of the forecasts.

4. The commodity analysis division does not develop forecast ranges based on either supply-and-demand uncertainty or alternative program implementation strategies.

Validating that the process accurately forecasts what will happen when payments are actually made is further complicated because USDA does not develop financial reports showing the total outlays by crop year.[11] In other words, the program is authorized by the Congress and implemented by the secretary from the cost and benefits for a crop year or a marketing year. However, after the analysts make the forecasts with crop year forecasts on supply and demand and program provisions and convert the information to a fiscal year basis, most financial tracking is by fiscal year. Some direct payments, such as deficiency payments, are tracked by crop year.

The analysts must forecast the fiscal year the payments will be made. For most provisions, most of the payments are made in the fiscal year following the crop year. But portions of an entitlement may be made over several years. Historical data are not readily available for reviewing the validity of the cost by crop year or for informing policymakers how much the program they authorized for a specific year actually cost.

[11]The projected cost by crop year or marketing year of the commodity programs that the secretary plans to implement is shown in regulatory impact statements published in the Federal Register. Sometimes this information shows the comparative costs of optional provisions but does not show the total expected costs. Actual net outlays are not tracked in a way that a comparison can be made between the regulatory impact statements and the financial statements.

Evaluation of Support Structure

Forecasting the USDA commodity budget requires that many disparate functions work together to produce an estimate of the cost of programs that several groups have responsibility for managing. It does not seem reasonable that all the knowledge and processes required to develop the budget could ever be assigned to one management structure. However, we could not find any description of all the components of budget forecasting, and the accountability for the components was spread among so many different officials that none seemed to be quite sure how process weaknesses or errors in components affected the budget estimate.

Although USDA recognizes that it has had accuracy problems with the budget estimates, no one management structure could act to see that improvements are made. USDA has corrected some weaknesses. It established and assigned responsibilities to WAOB. But as we discussed earlier, USDA policymakers have not made it clear whether the chair has any responsibility for the supply-and-demand estimates used for the president's budget. And in practice, the chair has not exercised such responsibility, either in approving the estimates or in ensuring that ASCS use the estimates developed by the interagency process.

Weaknesses That Limit Communication

Since no one management structure directs the many components, the quality of the budget forecast is highly dependent on the coordination and communication of the responsible analysts and officials. The management structure responsible for the forecast components is spread throughout various groups in USDA. USDA does not have documentation describing the process or identifying the analysts and officials accountable for the results and responsible for overseeing the quality and coordination of the many parts of the process.

We observed uncertainty in how economic forecasts are used in budget forecasting, lack of accountability and structure in the committee panel processes, different controls on approving supply-and-demand estimates for publication and for budget estimates, and lack of consistency and automation among the processes used for program volume estimates. In addition, policy changes made after estimates are made can have a significant effect on the accuracy of the budget estimates.

Because much of USDA's forecast methodology is not documented and cannot be replicated, USDA management is limited in its ability to share the strengths of its forecasting processes with other analysts and in evaluating the quality of forecasts. Decisionmakers are also limited because they are not always advised of the methodology used in devel-

oping the forecasts, the confidence level or range expected in the forecast, or error or bias.

Problems With Quality Control

The basic objective of a forecasting process, according to Bretschneider, is to produce forecasts at minimum costs that are timely, accurate, and appropriate.[12] We have emphasized throughout this report that the ultimate test of a forecasting methodology is the accuracy of its forecasts. If the accuracy of a forecast is not as good as it should be, then causes for error should be identified. A quality control program helps management select forecasting techniques, develop measures of uncertainty, identify areas for improvements, and produce better forecasts.

USDA does not have a structured quality control program or agency regulations setting standards for the evaluation of methodology and results, data management, and documentation and reporting. USDA's office of budget and program analysis has overall responsibility for budget preparation, but USDA's quality control program is primarily attained through the use of professional staff and normal supervisory review. Each organization that produces forecasts is responsible for its own quality control through normal management processes.

The individual USDA groups have made efforts to address some of the factors and accomplish some of the recommended practices either routinely or ad hoc. One positive action USDA took in 1986 was to establish a staff working group to evaluate concurrently with our evaluation the processes used to develop the budget estimates. The objectives were to review and describe the estimating process and review the accuracy of the estimates. Additional objectives were to determine whether errors would be reduced, examine the need to use forecast ranges, and evaluate bias in the forecasts. The working group included USDA officials and staff with key responsibilities for developing the CCC budget estimates. The group included members of USDA's office of budget and program analysis, ASCS's budget and commodity analysis divisions, WAOB, and the economic analysis staff of the assistant secretary for economics. The working group provided us an interim report that included the following suggested areas for improvement.

1. Use ranges or probability distributions to supplement the point estimates in budget presentations, for information about the apparent extent of the uncertainty of particular estimates and its major sources.

[12]Bretschneider, p. 15.

2. Improve USDA's coordination of available information, consistency of estimates, evaluative capability, and accountability and quality control through better documentation and the implementation of a tracking system and an estimates monitoring group.

3. Review and identify sources of bias in supply-and-demand estimates and program activity estimates in order to identify the potential for reducing the chances of systematic bias.

4. Enhance the analytical capacity available to the CCC estimation process, improve research support, and identify research needs to ERS and other researchers.

Summary

In order to produce timely, accurate, and appropriate forecasts of commodity program costs at minimum cost, USDA needs to improve the management of its forecasting processes in (1) evaluation of forecast methodology and results, (2) data management, (3) documentation and reporting, and (4) support structures for managing the processes.

The activities needed to ensure that best practices are followed could be grouped under a quality control program. But USDA does not have a structured quality control program or agency regulations setting standards for the above best practices. USDA does not systematically identify the causes for error and commit resources to improvement.

A quality control program should include ongoing evaluation that develops a data base on past or current programs and policies and a framework or foundation for applying the lessons learned to programs and policies of the future. Although the budget analysts have historically made evaluations for budget reconciliation, their analyses correlate misestimates at the outlay level with major events and do not relate errors in the forecast to the reasons for them. The evaluation of the working group is an excellent start, and its findings generally agree with ours.

We believe that USDA's reviewing the accuracy of supply-and-demand estimates, implementing the recommendations of its study, and incorporating the principles we identified into a quality control program may improve forecasting. To the extent that forecast accuracy cannot be improved, the information will provide decisionmakers a better description of the limitations of the information. The improvements will help coordination and communication between decisionmakers and analysts.

Conclusions and Recommendations

Multibillion dollar differences between USDA's forecasted cost of the commodity programs in the president's budget estimate and the actual net outlays are of concern to the Congress. These estimates have not provided accurate information for the Congress to use for monitoring the program or managing the deficit. Since the commodity programs ar entitlement programs in which the Congress must generally modify the authorizing legislation to affect the expenditure level, the Congress needs information that is as accurate and timely as possible. The admi istration also needs accurate and timely forecasts because the secretar of USDA can affect spending levels through discretionary authority. Although the administration makes many of its policy decisions after considering the forecasted effect of alternative strategies for a specific program provision, nonetheless it needs accurate budget estimates to know the total cost of the commodity programs.

USDA updates the forecasted costs of the commodity programs for budg updates. These forecasts have large errors, but they are progressively more accurate as forecasted information, such as farmers' participatio in the programs and planted acres, is replaced with actual data. Since the budget updates and the policy analyses are developed under the same general procedures that we describe in this report, our recommendations may be just as appropriate for those forecasts.

Conclusions

During the 15-year period 1972-86, USDA made forecasting errors (absolute error) averaging $4.3 billion per year and totaling $64.1 billion for the period. USDA underestimated the cost of the program (bias error) an average of $3.1 billion per year and a total of $46.8 billion for the period.

The forecasting errors have seemed especially large during the last 6 years, when 81 percent of the absolute error, or $52 billion, occurred. We found, however, that the dramatic increase in error was caused mor by the increase in program outlays than by significant increases in erro rates. Error rates for the 15-year period were 58.6 percent, and they increased to 63.2 percent during the last 5 years. We believe that since the Congress and the administration rely on budget estimates in making decisions, USDA must take action to ensure it is using the best forecasting practices. It should improve the accuracy of the forecasts; to the extent that errors will always exist, the improvements will enable USDA to describe the limitations of the forecast information.

Improving the accuracy of the president's budget estimate will not be easy. Forecasting the costs of an entitlement program always contains uncertainties. Some of the uncertainties the analysts must contend with are farmers' participation and the difficulties in forecasting supply-and-demand variables, which are affected by such factors as the weather and domestic and world economic conditions. Furthermore, the implementation strategy for the commodity programs can be modified after the analysts make the budget forecasts.

We conclude that USDA's management of the forecasting process may be contributing to the forecasting errors. Although USDA has allocated both resources and talent to making the forecasts, it has not placed the emphasis on or allocated resources for ensuring that the forecasting process meets best practices or that the forecasts provide accurate information for policymakers.

The quality of a forecast depends essentially on the accuracy of its outcomes. While most officials and policymakers have known that USDA's forecasts of the commodity programs have historically contained large components of error and are frequently biased toward underestimating the cost of the programs, USDA has not systematically identified the reasons for error and tried to correct the problems.

Recommendations

To improve the forecast accuracy of commodity program costs, USDA should improve the management of its forecasting processes in the areas of evaluation, forecast methodology, data management, and documentation and reporting. To the extent that forecast accuracy can be improved, policymakers will have better information about the assumptions used to develop the forecasts and the limitations of the information. These recommended practices emerge from three general sources: (1) practices recommended by forecasting experts, (2) other practices recommended in the literature, and (3) improvements recommended by the USDA working group on budget error.

Specifically, we recommend that the secretary of the U.S. Department of Agriculture assign management responsibility for coordinating the forecasting program and for establishing a structured quality control program to a specific organization. USDA should include best practices for evaluation of forecast methodology and results, data management, documentation and reporting, and support structures for managing the processes.

USDA should establish an on-going evaluation program that ensures that forecasters regularly perform studies of forecast accuracy to determine what caused errors and to relate the errors to the components of the forecasting processes, so that resources can be allocated for improvement.

USDA should establish standards and procedures for selecting and validating its forecasting methodologies. Some improvements to consider ar

1. Automate forecasting methods where possible for consistency and to facilitate sensitivity analysis, among other things.

2. Make the interagency panel process more structured, in order to improve accountability for forecast accuracy and reduce bias, and require the same review and approval for the supply-and-demand estimates used for the president's budget as for published estimates.

3. Validate the forecast method with such techniques as peer review by USDA and outside experts and comparison to combined forecasts of other techniques and to naive modeling.

USDA should establish recordkeeping systems based on best data management practices. Some recommended practices are

1. Require that analysts get approval to deviate from using the approved USDA supply-and-demand estimates.

2. Develop automated data bases of input data and forecast and actual data and maintain records of events or actions affecting forecast accuracy as part of normal recordkeeping. Such records are needed for making forecasts and accuracy studies.

USDA should ensure that the forecasting process and its results are documented and that forecast results include explanations of the limitations of the data, including forecast ranges based on historical error rates, alternative program implementation strategies, and alternative assumptions regarding supply and demand.

We also recommend that the secretary consider the recommendations made by the USDA working group established to evaluate the processes used to develop the budget estimates, many of which are in general agreement with this report.

Agency Comments and Our Response

USDA agreed with many of our findings. It emphasized in its comments on a draft of this report that its parallel study also found the need for improving the management of its forecasting process. While agreeing with most of our recommendations, USDA thought that we should have looked at the forecasting process in terms of all its output, including updated budget estimates, since some of the policy decisions are based on them rather than on the original budget estimates. USDA pointed out that because of the many inherent uncertainties in forecasting the cost of the commodity programs, neither its own nor our analysis provides clear evidence that improvements in the estimating process will measurably improve forecast accuracy. Nevertheless, USDA believes the improvements should be made.

While we fully recognize the difficulty of USDA's commodity budget forecast tasks, we suggest that many of USDA's comments did not address our report's theme, which was ways to improve budget estimates and the underlying forecasts, or quality control processes. Accordingly, we have not revised our conclusions and recommendations. (We have addressed these and other concerns in appendix VII, and we revised the report where appropriate.)

Request Letter

NINETY-NINTH CONGRESS

Congress of the United States
House of Representatives

GOVERNMENT INFORMATION, JUSTICE, AND AGRICULTURE
SUBCOMMITTEE
OF THE
COMMITTEE ON GOVERNMENT OPERATIONS
B-349-C RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515

April 17, 1986

The Honorable Charles A. Bowsher
Comptroller General of the United States
U.S. General Accounting Office
441 G. Street N.W.
Washington, D.C. 20548

Dear Mr. Bowsher:

I understand that your Program Evaluation and Methodology Division is starting work on the accuracy of USDA forecasts used for design, budget and implementation decisions for agricultural programs. As that topic is of great interest to this subcommittee, I am requesting that the results of that work be addressed to us.

I understand that the initial work will estimate the overall accuracy of Commodity Credit Corporation budget forecasts, and the accuracy of critical variables used to make the budget forecasts. I also understand the work will review USDA's procedures for ensuring the accuracy of its forecasts.

We would like to be briefed on the results of this phase of the work as soon as it is finished. The following questions would be of interest to the subcommittee.

- How do policy makers use forecasts based on computer models in designing, budgeting and implementing agricultural commodity programs?
- How accurate are the forecasts used for policy decisions for designing, budgeting and implementing decisions?
- What models or analyses techniques are used to develop the forecasts?
- What are the factors that contribute the greatest error in the forecasts?
- To what extent has USDA implemented quality controls to ensure the accuracy of forecasts using computer models?

I understand that the second part of the work will focus on problems in the forecasting methodology for several commodities and on possible ways in which policy makers might be better served. I am requesting that a report addressing the above issues plus the following questions also be addressed to this subcommittee.

- What problems are there in USDA forecasting methodologies?
- What problems are there in coordination and communication between analysts and decision makers?
- What promising practices might be adopted by USDA to improve the accuracy of its forecasts and to better ensure that forecasts meet the needs of policy makers?

I would hope that you would be able to brief us with the preliminary results of your analysis of forecasting accuracy and your description of USDA methods and quality control procedures by September 1, 1986. We can agree on a date for the report on the total analysis at that time. I request that your staff coordinate their efforts with Bill Cherry of the subcommittee staff. He may be reached in Room B349-C, Rayburn House Office Building, telephone 202/225-3741.

Thank you for your consideration of this request.

Sincerely,

Glenn English
Chairman

Key Program Provisions

U.S. farm policy has a number of methods to support and stabilize the prices of a number of specified agriculture commodities.[1] These methods have their roots in the Agriculture Adjustment Act of 1938 and the Agricultural Act of 1949 but are guided mainly by the Food Security Act of 1985.

U.S. farm programs use these methods to support and stabilize producer prices and incomes while assuring consumers of ample supplies. The most commonly recognized methods are

- price supports, including nonrecourse loans and government purchases;
- income supports, including deficiency, incentive, and disaster payments and
- supply management, including acreage allotments, marketing quotas, acreage set-asides and reductions, cropland and dairy diversion, payment in kind, and farmer-owned and long-term conservation reserve.

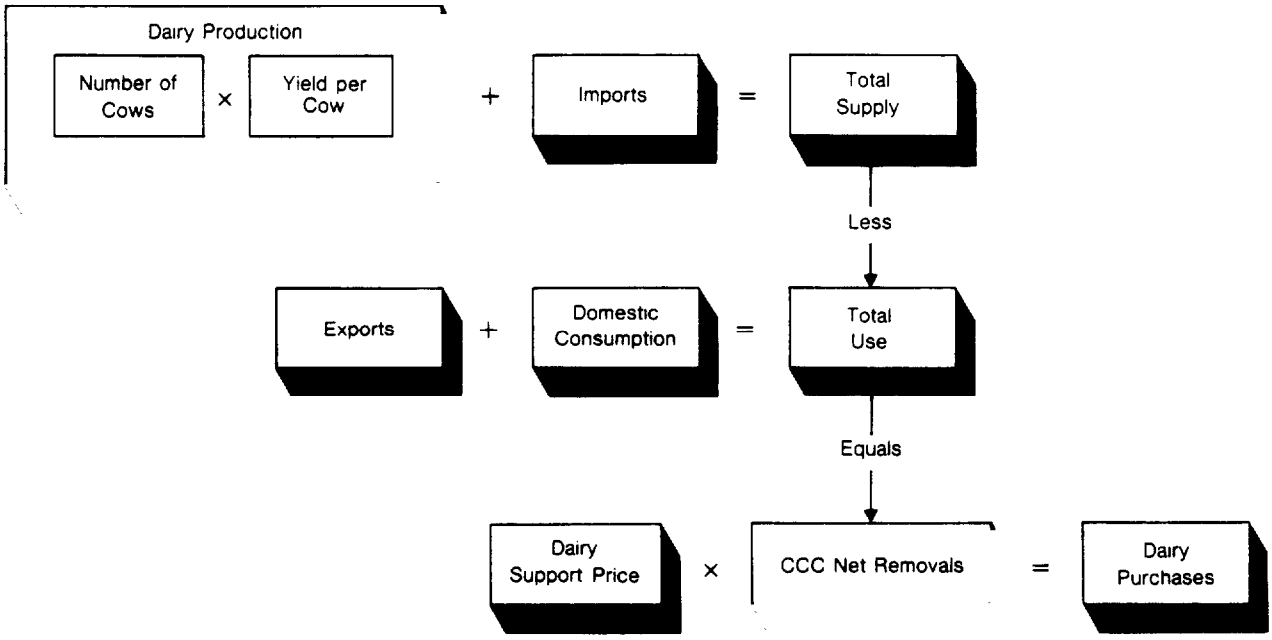
Federal commodity programs are available for corn, wheat, rice, peanuts, tobacco, wool, mohair, honey, oats, barley, rye, grain sorghum, soybeans, sugar, cotton, and milk. Some of these commodities, such as grains and cotton, are assisted by a number of the tools above, which work in concert. For example, farmers who want to qualify for nonrecourse loans and deficiency payments must participate in applicable acreage reduction programs.

Dairy Purchases

The government supports the price of milk chiefly through the dairy price support program. CCC indirectly supports the farm price of milk by offering to buy car lots of butter, cheese, and nonfat dry milk from processors at set prices per pound. To acquire dairy products, commercial distributors must offer milk processors as much as or more than CCC would pay. Dairy purchases are the amount of dairy commodities that the government purchases under the price support program. See figure II.1.

[1]The narrative in this appendix was adapted from Geoffrey Becker, Fundamentals of Domestic Commodity Price Support Programs (Washington, D.C.: Congressional Research Service, [illegible] 1985). We developed the "visual equations" in coordination with the commodity analysts in ASCS's commodity analysis division.

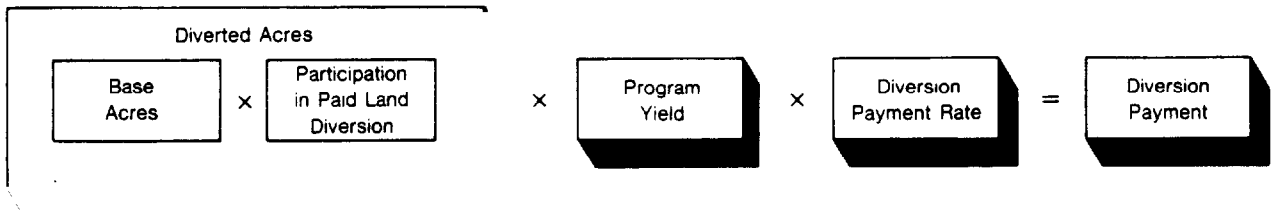
Figure II.1: Basic Provisions for Dairy Purchases



Paid Acreage Diversion

Payments are made to farmers who voluntarily reduce their planted acreage of a program crop and devote the land to a conservation use when a paid acreage diversion is in effect. The payments can be in cash or in surplus USDA commodities. USDA refers to the latter as "payment in kind." See figure II.2.

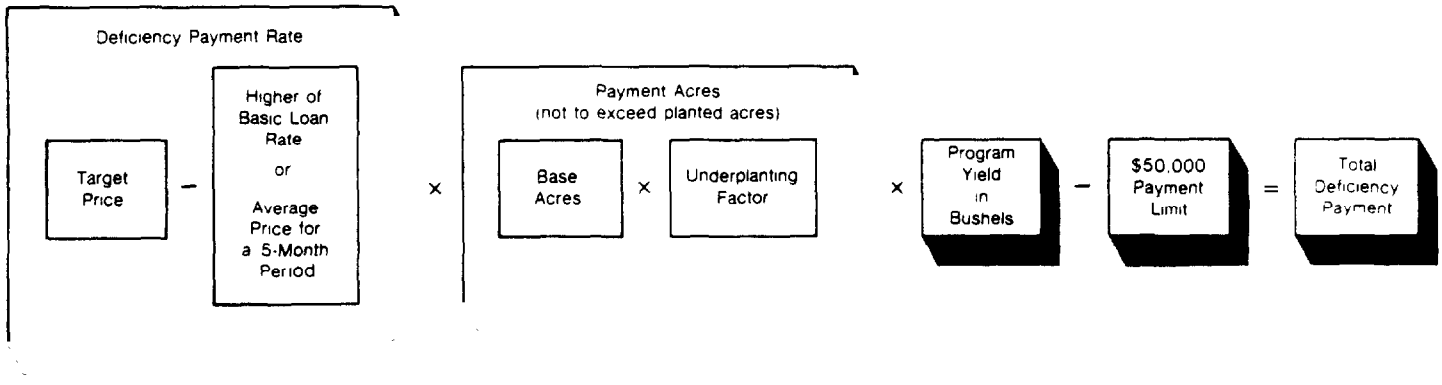
Figure II.2: Basic Provisions for Paid Acreage Diversion



Price Deficiency Payments

The government makes direct payments to farmers when farm prices are below target levels. The payment is arrived at by subtracting from the target price the higher of the loan rate or the national average price of a commodity during the first 5 months of the marketing year. The government generally pays this difference to a farmer who qualifies (by meeting all farm program conditions) for the portion of production specified in the farm program. See figure II.3.

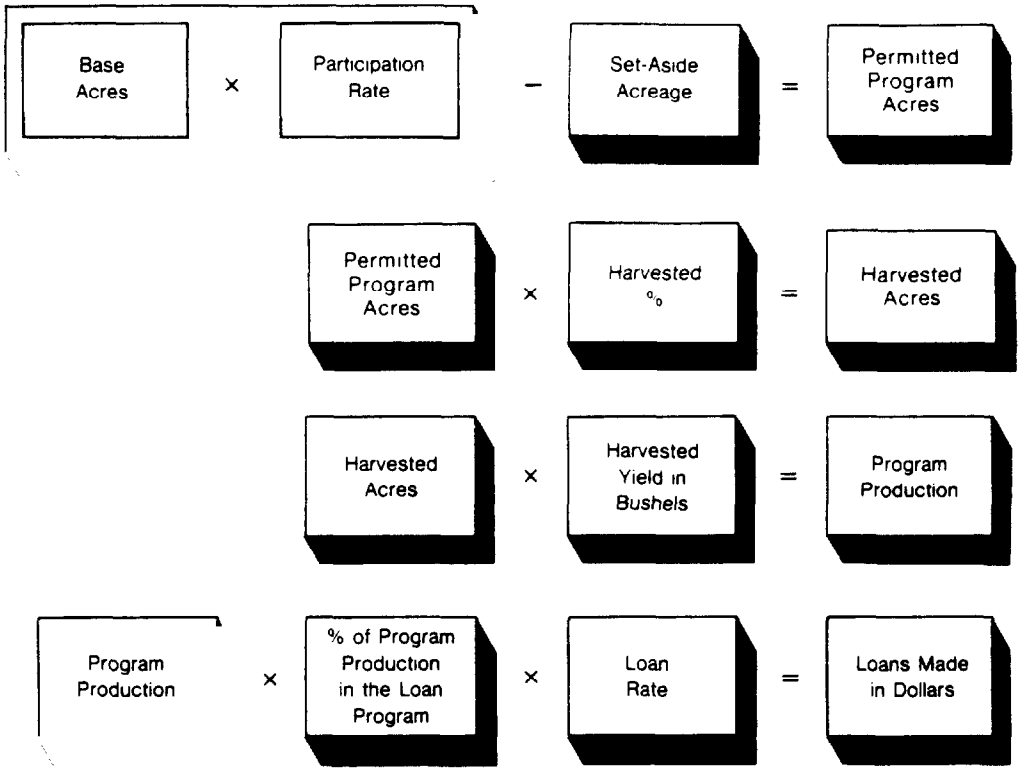
Figure II.3: Basic Provisions for Price Deficiency Payments



Nonrecourse Loans

Eligible farmers may obtain nonrecourse loans from CCC by using their commodities as collateral. Farmers who can sell a crop for a higher market price per bushel than the CCC loan rate repay the CCC loan and its interest. However, farmers who cannot earn enough on the market to profitably repay a loan before it matures (usually 9 to 12 months) simply forfeit the crop to CCC. It is "nonrecourse" because CCC takes title to the stored commodity as full payment of the loan. The Food Security Act of 1985 authorized an exception to this rule, known as "marketing loan." Under the marketing loan, the farmer can redeem the crop at the lower of the loan rate or market price. See figure II.4.

Figure II.4: Basic Provisions for Nonrecourse Loans



Formulas for Accuracy Measures

This appendix includes background information and formulas for measuring forecast accuracy. The concepts and formulas are drawn from the work of forecasting experts such as Armstrong, Ascher, Makridakis, and Bretschneider.[1]

Background on Measures of Accuracy

Our four types of measure for evaluating the accuracy of the budget forecasts and the component forecasts USDA uses for developing the budget forecasts were (1) benchmarks, (2) single forecast error (1-year time period), (3) total error over multiple forecasts, and (4) bias error.

"Error" for a single forecast is the difference between the actual observation and the forecast and reflects whether the forecast is under or over the actual value. The sum of the single forecast errors for a time series of forecasts is the "net error" and indicates whether the forecasts over time are random or are systematically over- or underestimated—that is, biased. Because a totally random pattern of forecast error would have a zero net error, we assume the amount over zero reflects the amount of bias. The sum of the absolute values of the single forecast errors for a time series is the "total absolute error" and measures the total error, regardless of the direction of yearly errors; therefore, it includes both bias and random error.

Each of the measures we included has strengths and weaknesses. For example, some measures make adjustments to avoid excessive emphasis on extreme errors, or outliers, in any one forecast. Other measures provide extra penalty for extreme errors. Most of the measures can also be calculated as a percentage that provides a comparison between errors with different baselines or different time periods. In selecting measures, an evaluator must consider the availability of data and the use to be made of the measures.

Benchmarking

The best way to determine if the accuracy of a forecast is reasonable is to compare it to forecasts from other models. Using other forecasts as benchmarks helps analysts and policymakers evaluate how comfortable

[1]J. Scott Armstrong, Long-Range Forecasting: From Crystal Ball to Computer, 2nd ed. (New York: John Wiley and Sons, 1985); William Ascher, Forecasting: An Appraisal for Policy-Makers and Planners (Baltimore: John Hopkins University Press, 1978); Spyros Makridakis et al., The Forecasting Accuracy of Major Time-Series Methods (New York: John Wiley and Sons, 1984); Stuart Bretschneider, personal communication, and "Forecasting: Some New Realities," Maxwell School Studies Program, Syracuse University, Syracuse, New York, December 1985.

they should be with the accuracy of the forecast. In addition to determining accuracy relative to other methods, this technique offers the opportunity to evaluate a forecast's methodological reliability during postanalysis. Comparison models should start with simple, low-cost comparisons.

Statistical trends using the latest available actual data are the basis for naive models. The simplest naive forecast uses the last data point available as the value of the forecast into the future.

Comparing a forecast to the results of other forecasters in similar situations is another way of judging whether the forecast could be more accurate. Comparison can be to specific single forecasts or combined forecasts. Forecasts can be combined as means, trimmed means, or weighted averages.

Finally, comparison can be made to the results of methodologies different from the one used to produce a forecast, and comparisons can be made of forecasts made for the same length of time but in different years. This latter type of comparison produces information about historical accuracy.

Benchmarking allows forecasters and forecast users to evaluate the relative accuracy of several forecasts. If similar forecasts are being made by two or more forecasters, the forecasts can be compared individually. Likewise, the comparison forecasts can be combined, in order to develop a single forecast for comparison. Another method is to develop a comparison forecast with a naive model that uses historical trend data without judgments about the future.

Forecasts made with naive models or consensus methods can provide two types of checks. First, they help establish acceptable error and bias rates for a specific type of forecast. For example, one agriculture forecaster considers error rates greater than those of a naive model to be unacceptable, believing that a reasonable goal for errors may be three fourths or less of the number generated by a naive model.[2] Second, benchmarks provide a means of questioning the methodology being used to generate forecasts. If postanalysis shows that comparison forecasts are more accurate over time, then the methodology being used is questionable.

[2]John Ferris, "Evaluation of Forecasts from the Annual AAEA Outlook Survey," presented at the annual meeting of the American Agricultural Economics Association, Reno, Nevada, July 1985.

The Concept of Error

For a single forecast, the difference between the forecast (F) and the actual (A) value is the error (E). That is, E = A − F. The single forecast error may be positive or negative. It does not have much value for gauging the quality of a forecasting model, but multiple forecasts over time can be used to show how well a forecasting procedure is working.

To analyze forecasting methods, single forecast error can be separated into two parts. One part is called "random error" and it varies unsystematically from one forecast to the next. The other part is called "bias error" and it remains constant for any particular forecasting procedure. Table III.1 shows hypothetical data for a series of 10 forecasts.

Table III.1: Hypothetical Data Demonstrating Forecast Error[a]

		Error		
Actual	Forecast	Single forecast	Random	Bia
27	20	7	4	
16	18	(2)	(5)	
32	29	3	0	
25	26	(1)	(4)	
21	21	0	(3)	
19	15	4	1	
27	22	5	2	
29	23	6	3	
17	15	2	(1)	
34	28	6	3	
24.7	**21.7**	**3**	**0**	

[a]Numbers in the final row are means.

The behavior of the random and bias portions of error in a hypothetical forecasting process can be seen from the table. The mean error over the time series is 3. The random error, while it fluctuates considerably, has a mean of 0. Over many forecasts, the mean of the random error equals 0 because it is defined as unsystematic error and random errors tend to offset one another. The bias part of the error in this hypothetical example is 3 in every forecast. Measured by the mean error measure, this bias indicates that every forecast is too low by 3 points.

Actual forecasting procedures are rarely this consistent. If the forecasting procedure is changed, no bias will be consistent from period to period, particularly when the forecast has several input variables or is made up of several component forecasts. For complex models, bias can come from any of the input variables or component forecasts and generally varies with each single forecast in a time series.

The length of the time series or number of data points affects the statistical validity of the measurements. We do not believe, however, that the evaluation of forecasts can always be put off until there is sufficient time to make statistically accurate measurements. Management needs timely evaluations of forecasts to improve the credibility of forecasts and to ensure that decisionmakers are getting the information they need.

In analyzing error in multiple forecasts, we concentrated on absolute error measures and bias error measures. We refer to the absolute error measures as total error because total error is the sum of random and bias error. It is important to measure bias because research has shown that its causes can frequently be isolated and corrected. As we stated above, the error measures of a forecast can be compared to other forecasts, or benchmarks, to determine their relative accuracy.

Measures of Single Forecast Error

The basic error measurements are for a single forecast. These measurements stress identifying the deviation between actual data and the forecast. In all cases, the actual serves as the base, the forecast being deducted. As we stated above, error (E) is defined as $E = A - F$, or the difference between A and F.

Absolute error (AE) is defined as

$$AE = |E|$$

and is a measure of error without regard to whether the forecast is overestimated or underestimated.

Percentage error (PE) is defined as $PE = E/A \times 100$. That is, PE is the product of the error divided by the actual, multiplied by 100. The measure shows whether the error is negative or positive. The percentage error measurement favors forecasts that are less than the actual, or underestimates. If the forecast is less, the error cannot exceed 100 percent, but there is no limit to the percentage error for overestimates.

Absolute percentage error (APE) is defined as

$$APE = \frac{|E|}{A} \times 100.$$

It is absolute error divided by the actual multiplied by 100. The absolut percentage error measurement also favors forecasts that are less than the actual, or underestimates. If a forecast is less, the error cannot exceed 100 percent, but there is no limit to the percentage error for overestimates.

Measures of Total Error

Absolute measures over multiple forecasts show total error. Total, or absolute, error measures over a time series of forecasts ($F_1, F_2, \ldots, F_n$) and actual observations ($A_1, A_2, \ldots, A_n$) include total absolute error (TAE), mean absolute error (MAE), mean absolute percentage error (MAPE), adjusted mean absolute percentage error (AMAPE), root mean squared error (RMSE), and root mean squared percentage error (RMSPE). One measure, AMAPE, adjusts the results so that they are no skewed by high or low single-period measures.

Total absolute error (TAE) is the sum of the single forecast absolute errors, or

$$TAE = \sum_{i=1}^{n} |E_i|.$$

Mean absolute error (MAE) is defined as MAE = TAE/n. It is the sum of absolute errors over multiple forecasts divided by number of forecasts. MAE shows the average or typical error but does not distinguish between random error and bias error. This is also called the mean absolute deviation (MAD).

Mean absolute percentage error (MAPE) is defined as

$$MAPE = \left(\frac{\sum_{i=1}^{n} \frac{|E_i|}{A_i}}{n} \right) \times 100$$

or the sum of the absolute percentage error (absolute error for each forecast divided by actual observations) divided by the number of forecasts. MAPE is dimensionless and useful for comparing forecasts from

different situations. The measurement favors forecasts that are less than the actual in the sense that a low forecast can never be wrong by more than 100 percent, but the percentage error on the high side has no limit.

Adjusted mean absolute percentage error (AMAPE) is defined as

$$\text{AMAPE} = \left[\frac{\sum_{i=1}^{n} \frac{A_i - F_i}{\frac{1}{2}(A_i + F_i)}}{n} \right] \times 100.$$

Although similar to MAPE, AMAPE does not favor low forecasts. The sum of the absolute error for each period is divided by half the actual plus the forecast. This is then divided by the number of periods. The result is multiplied by 100. AMAPE is also less sensitive to measurement error in actual data.

Root mean squared error (RMSE) is calculated by taking the square root of the sum of the square of the actual minus the forecast divided by the number of forecasts:

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} E_i^2}{n}}$$

Extreme variances have a strong effect on the measure because they are squared.

Root mean squared percentage error (RMSPE) is defined as

$$\text{RMSPE} = \left(\frac{\sqrt{\frac{\sum_{i=1}^{n} E_i^2}{n}}}{\frac{\sum_{i=1}^{n} A_i}{n}} \right) \times 100.$$

RMSPE is calculated by first taking the square root of the sum of the actual minus the forecast squared divided by the number of observations. This result is then divided by the sum of the actual divided by the number of observations, and the whole is multiplied by 100.

Measures of Bias Error

Bias measures consider underestimates and overestimates. It is important to identify bias, because it happens when factors other than random events are influencing the forecasts. It may be possible to make changes that lessen bias. Bias must be measured over several observations to avoid mistaking it for random error. Bias measures include net error, mean error, mean percentage error, trimmed mean error, and trimmed mean percentage error.

Net error (NE) is defined as

$$NE = \sum_{i=1}^{n} E_i$$

or the sum of the errors for each period with regard to whether the forecast was underestimated or overestimated. It is a measure of bias over multiple forecasts, because the net error would be 0 if the single forecast errors were random.

Mean error (ME) is the average of the errors with regard to underestimates and overestimates; that is, ME = NE/n. The mean error would be 0 if the single forecast errors were random. Mean error gives a measure of the bias of individual forecasts in a time series.

Mean percentage error (MPE) is defined as

$$MPE = \left(\frac{\sum_{i=1}^{n} \frac{E_i}{A_i}}{n} \right) \times 100.$$

MPE is the sum of the percentage errors, whether underestimates or overestimates, divided by the number of forecasts and multiplied by 100. The mean percentage error measure favors estimates that are less than the actual. An underestimate can never be wrong by more than 100 percent (when the forecast is not less than 0), but the percentage error on the high side has no limit.

Trimmed mean error (TME) is the sum of all single-forecast errors minus the highest and the lowest values. The result is divided by the number of forecasts less 2 (where the largest and smallest E_i's are dropped). That is, $TME = \Sigma E_i/(n-2)$.

Trimmed mean percentage error (TMPE) is defined as

$$TMPE = \left(\frac{\Sigma \frac{E_i}{A_i}}{n-2} \right) \times 100.$$

where the largest and smallest E_i's are dropped. The trimmed mean percentage error is calculated by summing all single-forecast errors, deducting the highest and lowest values, and dividing by the number of forecasts less 2. The product is then multiplied by 100 to arrive at the percentage.

The Popularity of Measures

Armstrong presents a table summarizing the popularity of various forecast measurement formulas. The summary, indicated in table III.2, is based on a questionnaire filled out at the first international symposium on forecasting in Quebec in 1981. It did not include all the measures we have discussed in this appendix (and did include two we have not discussed). The major exclusion related to the trimmed mean, which USDA uses because of its legislative requirements.

Table III.2: The Percentage of Times Forecasters Mentioned Accuracy Measures[a]

Measure	Academics	Practitioners
Root mean squared error	48%	32%
Mean absolute error	19	22
Mean absolute percentage error	24	14
Mean percentage error	8	8
Theil's U	5	2
R square	0	3

[a]The percentages are based on questionnaire answers saying that accuracy was relevant (63 answered the questionnaire in both groups). Some did not mention a specific measure; others mentioned more than one. Thus, the columns do not equal 100 percent

Differences Between Net Outlays and Net Realized Losses

Two cost concepts, "net outlays" and "net realized losses," must be understood when discussing the funding of USDA's farm programs. Although net outlays and net realized losses are related, they are not interchangeable. Net outlays is a measure of the amount of money CCC disburses during a fiscal year to pay the entitlements for the prior marketing year, and net realized losses is a measure of the net outlays that will never be recovered. CCC disburses and receives all outlays and receipts for the farm programs. CCC's actual funding, however, is not based directly on the net outlays from the CCC fund.

Net outlays consist of all cash outlays less all cash receipts. The concep measures cash flow, or the amount of money CCC spends in a given fisca year on the major commodity price and income support programs. Receipts come from farmers' loan repayments or from CCC's sales of some of the surpluses it has acquired. Forecasts of net outlays are made for each commodity and summed for an estimate of total outlays. At the end of any given fiscal year, CCC has almost always disbursed more money than it has taken in. The difference is recorded as net outlays.

From a budget perspective, net outlays accurately reflect the drawdown of federal resources during the fiscal year and are used to estimate the deficit. The estimated net outlays are the basis for the president's budget estimate and the subsequent updates on the cost of the farm program during a fiscal year. When USDA misestimates the net outlays, the Congress does not initially have timely and reliable information to monitor the cost of the farm program or the adequacy of program funding.

Net realized losses describe outlays CCC will never recover and that are the basis for appropriations. Net realized losses are reflected in the financial statements and include losses on the disposal of assets and direct payments to farmers. Commodities obtained from forfeited loans or purchases are asset acquisitions. For example, wheat is obtained from loan forfeitures, and dairy products are obtained from purchase agreements. A commodity asset acquisition is not considered expenses until the asset is disposed of. At the time of disposition, the amount CCC receives for the commodity is compared to the acquisition price CCC paid for the commodity, and the difference is recorded as either a loss or a profit to the program. Most dispositions result in losses. In addition, the direct payments CCC makes to farmers for such expenses as deficiency payments and paid land diversion are not recoverable. Net realized losses include commercial storage and transportation payments, interest payments on borrowing from the U.S. Treasury, and general operating expenses.

CCC finances its operations (net outlays) through its borrowing authority within a $25 billion limit set by the Congress. Each fiscal year, an amount of money sufficient to reimburse CCC for its net realized losses, as reflected in its annual financial report, is authorized for appropriation. Appropriations, along with program receipts, are always used to repay outstanding loans from the Treasury, thus restoring CCC borrowing ability in a continuing cycle of operations. In the past, the losses were reimbursed 2 years after they occurred and as part of the normal appropriation process.

In recent years, farmers' heavy reliance on the commodity programs, the limit on borrowing authority, and the encumbrance of virtually the entire borrowing authority by loan and inventory investment have forced CCC to come to the Congress several times during the fiscal year for additional money. To meet CCC's current cash-flow needs, the administration has requested supplemental appropriations that are based on estimated future net realized losses. Without appropriations for both current and estimated losses, CCC would exhaust its borrowing authority before it would normally receive its appropriations for actual net realized losses.

From fiscal year 1982 to 1986, the Congress enacted eight supplemental appropriations for emergency reimbursement of CCC net realized losses. In fiscal year 1986, CCC required four of these supplementals, totaling about $16 billion, and CCC ceased operations four times during a 10-month period in 1985 and 1986 because of insufficient funds. Table IV.1 shows the initial $9.1 billion and the $15.8 billion in supplemental appropriations during fiscal year 1986 to the CCC fund.

Table IV.1: Fiscal Year 1986 Appropriations and Supplementals

Legislation	Amount in billions
Initial appropriation	
October 1985	$9.1
Supplemental	
December 1985	4.0
February 1986	1.5
March 1986	5.0
July 1986	5.3
Total	**$24.9**

Figure IV.1 shows the relationship of budget estimates to net outlays from the fund, as well as the sources for replenishing the CCC fund. Figure IV.2 and table IV.2 show that during 1979-86, net outlays totaled

$91.2 billion and net realized losses totaled $75.7 billion. One reason net outlays for the period exceed net realized losses is that CCC acquired commodities through loan defaults and purchases that were not considered expenses in the net realized losses until they were disposed of.

Figure IV.1: CCC Fund Operation

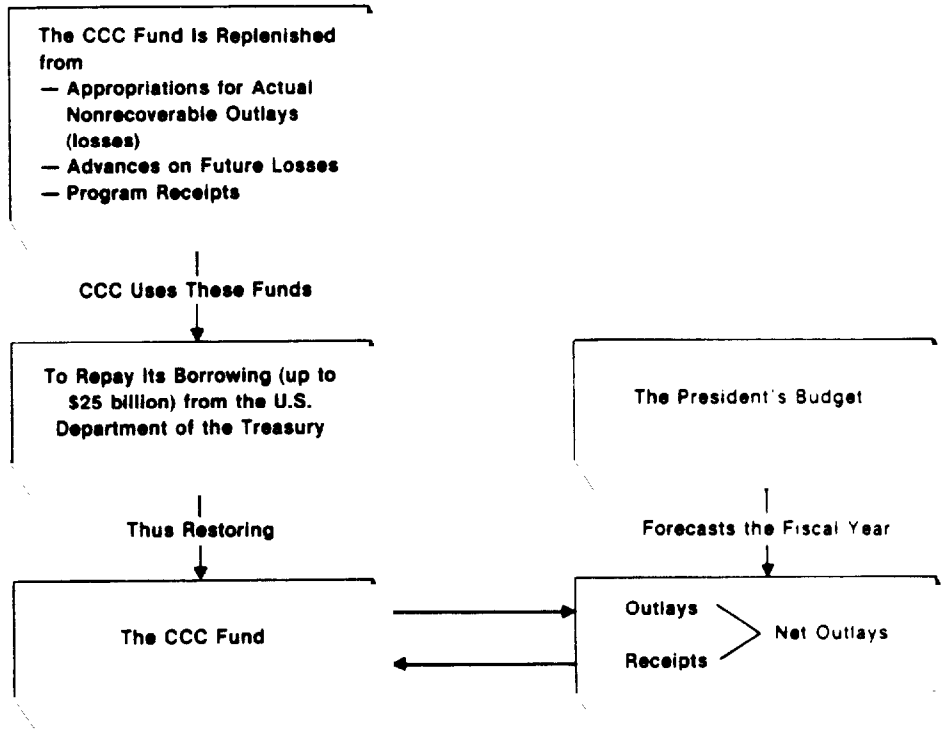


Figure IV.2: Net Outlays and Net Realized Losses Fiscal Years 1979-86

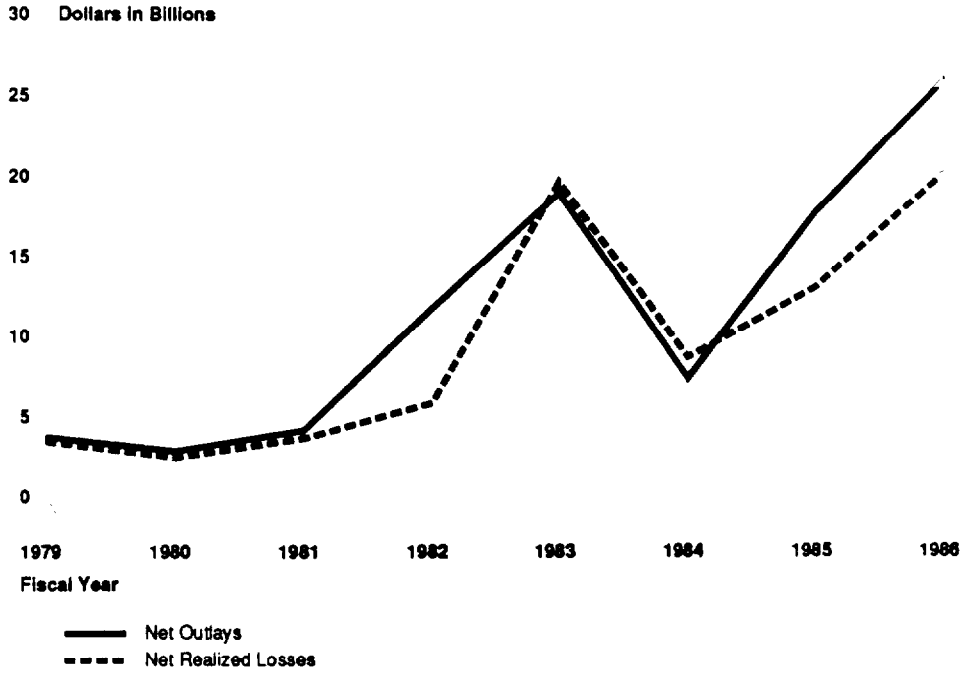


Table IV.2: CCC Net Outlays and Net Realized Losses 1979-86[a]

Action	1979	1980	1981	1982	1983	1984	1985	1986	Total
Net outlay									
Payments									
Loans	$4.6	$4.2	$5.8	$11.5	$13.7	$5.1	$10.4	$17.7	**$73.0**
Purchases	0.7	2.6	2.5	2.6	7.6	7.7	2.6	4.2	**30.5**
Cash direct payments (deficiency, diversion, and disaster)	1.8	0.4	1.0	1.5	3.6	2.1	7.8	6.2	**24.4**
Producer storage payments	0.2	0.3	•	0.7	1.0	0.3	0.3	0.5	**3.3**
Storage, handling, and transportation	0.1	0.2	0.3	0.4	0.6	0.5	0.5	0.9	**3.5**
Export activities	1.5	1.1	0.1	0.4	0.5	0.8	0.2	0.3	**4.9**
Operating expenses	•	•	0.2	0.3	0.3	0.4	0.4	0.5	**2.1**
Interest expenses	1.0	1.1	1.2	0.1	4.0	1.6	1.9	2.2	**13.1**
Other	•	0.3	0.8	•	1.0	9.1	1.1	4.0	**16.3**
Total	**9.9**	**10.2**	**11.9**	**17.5**	**32.3**	**27.6**	**25.2**	**36.5**	171.1
Receipts									
Loan repayments	4.0	4.1	5.7	4.6	9.4	10.6	4.5	5.7	**48.6**
Sales proceeds	0.7	1.0	0.9	0.6	1.6	9.5	1.8	2.5	**18.6**
Export repayments	1.1	1.4	1.0	0.3	0.1	0.1	0.1	0.1	**4.3**
Other	0.6	0.7	1.1	0.2	0.9	1.6	1.0	2.8	**8.9**
Total	**6.4**	**7.2**	**8.7**	**5.7**	**12.0**	**21.8**	**7.4**	**11.2**	80.4
Change in working capital	0.1	(0.3)	0.8	(0.2)	(1.5)	1.4	(0.2)	0.4	**0.5**
Net outlay[b]	$3.6	$2.7	$4.0	$11.6	$18.8	$7.2	$17.6	$25.7	**91.2**
Net realized loss									
Certificates									
Deficiency and diversion	•	•	•	•	•	•	•	$2.7	**$2.7**
Other	•	•	•	•	•	•	•	0.7	**0.7**
Cash direct payments (deficiency, diversion, and disaster)	$1.9	$0.4	$1.0	$1.5	$4.7	$4.6	$7.3	9.9	**31.3**
Interest expense	0.6	0.6	0.6	2.0	1.5	1.0	1.7	0.9	**8.9**
Storage, handling, and transportation	0.3	0.5	0.3	0.3	0.6	0.6	0.5	0.9	**4.0**
Donations	0.1	0.2	0.4	0.6	1.4	1.6	2.5	1.7	**8.5**
Loss on sales	0.1	0.1	0.2	0.5	0.6	0.6	0.6	1.6	**4.3**
Payment in kind	•	•	•	•	9.4	0.3	(0.1)	0.1	**9.7**
Producer storage payments	0.2	0.3	0.1	0.5	1.1	0.3	0.3	0.3	**3.1**
Operating expenses	0.1	0.1	0.2	0.3	0.3	0.4	0.4	0.5	**2.3**
Net other expenses	•	0.1	0.7	•	(0.1)	(0.9)	(0.3)	0.7	**0.2**
Net loss	**$3.3**	**$2.3**	**$3.5**	**$5.7**	**$19.5**	**$8.5**	**$12.9**	**$20.0**	$75.7

[a]Dollars are for fiscal years in billions.

[b]Fiscal year 1983-86 purchases, other outlays, loan repayments, and sales proceeds include cash transactions that net to zero effect on net outlays.

Analysis of Wheat Budget Error

The wheat budget and its components make up the second largest component of error in the USDA commodity budget forecasts. They accounted for about 18 percent of the absolute dollar error during fiscal years 1981-86. USDA's wheat budget estimates and its two largest components were biased toward underestimation. USDA's forecasts exhibited larger error and bias than did a simple naive model.

In table V.1, we show the wheat budget errors year by year. The single forecast errors ranged from a low of 14.6 percent to a high of 83.0 percent. The analysts underestimated the budget each year. The average estimating error was $1.5 billion.

Table V.1: USDA Wheat Budget Forecast Error 1981-86[a]

	Error		Net outlay	
	Forecast	Actual	Single forecast[b]	Percent[c]
Fiscal year				
1981	$0 77	$1.54	$0.77	49 8
1982	0 63	2.23	1 60	71 5
1983	0 58	3.41	2 83	83 0
1984	2 15	2.52	0 37	14 6
1985	2.43	4.65	2 22	47 7
1986	2.11	3.39	1 28	37 7
Total[d]	**$8.68**	**$17.73**		
Error				
Total				
Absolute (TAE)			9 05	
Mean absolute (ME)			1 51	
Mean absolute percentage (MAE)				50 7
Root mean squared percentage (RMSPE)				58 3
Bias[e]				
Net (NE)			9 05	
Mean (ME)			1 51	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Percent errors were computed with exact numbers.

[d]Totals may not add because of rounding.

[e]Underestimated 6 of 6 years.

In table V.2, we show a comparison of the USDA wheat budget estimate to a naive forecast. The naive estimate exhibited a lower net error, a lower

absolute error, and lower percentage errors than USDA's estimate over the 6-year period. Percentage error measures also indicate that the simple naive forecast was more accurate than USDA's more complex forecasting process.

Table V.2: Comparison of USDA and Naive Model Wheat Budget Forecasts 1981-86[a]

	USDA			Naive		
	Forecast	**Error[b]**	**Percent**	**Forecast**	**Error[b]**	**Percent**
Fiscal year						
1981	$0.77	$0.77		$0 30	$1 24	
1982	0.63	1.60		0 87	1 36	
1983	0.58	2.83		1 54	1 87	
1984	2.15	0.37		2 23	0 29	
1985	2 43	2.22		3.41	1 24	
1986	2.11	1.28		2.52	0 87	
Total[c]	**$8.68**	**$9.05**		**$10.86**	**$6.87**	
Error						
Total						
Absolute (TAE)		$9.05			$6 87	
Mean absolute (MAE)		1 51			1 15	
Mean absolute percentage (MAPE)			50.7			43 4
Root mean squared percentage (RMPSE)			58.3			42 0
Bias[d]						
Net (NE)		9.05			6 87	
Mean (ME)		1.51			1 15	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Totals may not add because of rounding.

[d]Underestimated 6 of 6 years.

The absolute dollar error for the 6-year period was $9.05 billion. In table V.3, we show a breakdown of the wheat budget error into the various component payment categories. The data show that $4.74 billion, or 52.4 percent of the error in the wheat budget, was contained in the estimate of net lending (loans made less loans repaid). The second largest error was in deficiency payments, where the total error was $3.01 billion. Combining the 10 other categories, the total error amounts to $1.3 billion.

Table V.3: Cost Components of USDA Wheat Budget Total Error 1981-86[a]

Component	Error	Percent
Net lending	$4 74	52 4
Deficiency payments	3 01	33 3
Other (10 line items)	1 30	14 3
Total	**$9.05**	**100.0**

[a]Dollars are for fiscal years in billions

In table V.4, we apply three bias measures to the wheat budget component payments. The measures (net error, mean error, and occurrences) indicate a bias in the wheat payment estimates toward underestimation. USDA generally forecast that the spending for these budget components would be less than it actually was.

Table V.4: Bias Error in USDA Measures of Wheat Program Costs 1981-86

Cost component	Error[a]		Years costs were underestimated
	Net	Mean	
Net lending	$2.48	$0 41	5 of 6
Deficiency payments	1 82	0 30	4 of 6

[a]Dollars are for fiscal years in billions. Positive errors are underestimates.

We used sensitivity analysis to identify the key supply-and-demand variables influencing the error in USDA's wheat budget outlay estimates. The technique allowed us to evaluate the effect that changes in selected input variables have on budgetary outlays and other variables. We made the analysis using USDA's policy simulation models, developed by the economic analysis staff under USDA's assistant secretary for economics. The models are not used in the budget estimation process and were initially prepared to estimate the cost of the various proposals for 1985 farm legislation. The economic analysis staff uses the models to conduct policy simulation studies. We used the error rates in the model baseline for wheat crop year 1986 and projected the effect such error would have on outlays for fiscal year 1987 and for fiscal years 1987-89 in total.

Based on the combined effect of the error in the supply-and-demand estimates and the estimates underlying sensitivity to error, our analysis showed that the individual input variable with the largest effect on wheat budget outlay error was the interagency commodity estimates committee's estimate of wheat production, and the second largest effect came from the committee's estimate of wheat exports. Under the conditions of the model, the errors in total supply had about the same effect on the net outlay as the errors in total demand.

To identify the key wheat variables, we combined the results of our sensitivity analysis with the information we obtained from interviewing USDA analysts and the knowledge obtained from developing flowcharts describing the budget estimating process. We concluded that the most important variables in estimating the wheat net outlays and in forecasting net lending and deficiency payments are key supply-and-demand variables forecast by the committees. These key variables include production, domestic use, exports, and ending stocks.

In table V.5, we show the error and bias measures for the variables. The effect of these variables on net lending and deficiency payments are discussed briefly below and in appendix II. The mean error measures show that the USDA analysts tended to underestimate total supply and to estimate total use correctly. The result was that they underestimated ending stocks by about the same amount as they underestimated total supply. The analysts were correct in estimating total demand, because they underestimated domestic use by about the same amount as they overestimated exports. The error in total supply is composed about equally of errors in beginning stocks and production.

Table V.5: Total and Bias Error in USDA Wheat Supply-and-Demand Variables 1981-86[a]

		Bias		
Variable	**Error**	**Net**	**Mean**	**Occurrences in 6 years**
Summary				
Total supply	1,240	514	85.7	Underestimate 4 of 6
Total demand	1,055	15	2.5	Underestimate 4 of 6
Ending stocks	1,385	499	83.0	Underestimate 4 of 6
Input				
Beginning stocks	389	239	40	Underestimate 5 of 6
Production	949	249	42	Underestimate 4 of 6
Imports	26	26	4	Underestimate 5 of 6
Domestic use	565	435	73	Underestimate 4 of 6
Exports	1,226	(420)	(70)	Overestimate 4 of 6

[a]In millions of bushels for fiscal years. Positive errors are underestimates.

Errors in the wheat variable forecasts were smaller and more nearly random than the errors in the corn variables presented in chapter 3. For example, corn exports were overestimated for each of the 6 years, whereas wheat exports were underestimated in 2 and overestimated in 4. The corn exports mean error was a 436 million bushel overestimate, but the wheat exports mean error was considerably less, at a 70 million bushel overestimate.

We used two forecasts produced by private forecasters as benchmarks for the accuracy and bias of the USDA wheat budget forecasts. Using the AAEA survey, which compared USDA forecasts to a naive model and to private forecasts for crop years 1978-85, USDA's forecasts for three key wheat variables (production, exports, and price) were more accurate than either those of the AAEA survey or the naive model. As shown in table V.6, the AAEA forecasters made a better forecast of ending stocks, on the average.

Table V.6: Comparison of USDA, AAEA, and Naive Model Wheat Forecast Error[a]

Variable	USDA	AAEA	Naive[b]
Ending stocks	14.6	13.3[c]	18.4
Production	1.8[c]	3.7	11.4
Exports	10.9[c]	13.4	17.3

[a]Root mean squared percentage error. The comparison period is 8 years (crop years 1978-85).

[b]Uses previous year's actual as the forecast for forthcoming year.

[c]The most accurate of the three forecasts.

Source: Adapted from John Ferris, "Evaluation of Forecasts from the Annual AAEA Outlook Survey," presented at the annual meeting of the American Agricultural Association, Reno, Nevada, July 1986.

Private forecasters responding to a Futures survey made better forecasts, on the average, than USDA did for the wheat production and domestic use variables for crop year 1985-86. However, as shown in table V.7, the USDA analysts achieved lower error percentages on price, exports, and ending stocks than the private forecasters combined.

Table V.7: Comparison of USDA and Futures Wheat Forecast Mean Error[a]

Variable	Futures[b]	USDA
Supply and demand		
Total supply	(1.4)[c]	(2.5)
Total demand	(17.1)[c]	22.1)
Ending stocks	14.9[c]	[illegible]7
Components of supply and demand		
Beginning stocks	2.7	1.6)[c]
Production	(4.1)	3.5[illegible]
Domestic use	(4.8)	3.6)[illegible]
Exports	(31.2)[c]	43.4)

[a]Error is percent of actual.

[b]"How USDA 'Challengers' Did in Wheat," Futures, September 1986, p. 78.

[c]The most accurate of the two forecasts.

Analysis of Dairy Budget Error

The dairy budget and its components make up the third largest component of error in the USDA commodity budget forecasts, accounting for about 11 percent of the absolute dollar error during fiscal years 1981-86. USDA's dairy budget estimate and its most important component exhibited a bias toward underestimation. USDA's dairy budget estimate had a higher error and more bias than a simple naive model.

In table VI.1, we show the dairy budget errors year by year. The table shows that the dairy budget estimates are biased toward underestimation. Over the 6-year period, the analysts underestimated dairy program spending by an average of almost $1 billion dollars each year.

Table VI.1: USDA Dairy Budget Forecast Error 1981-86[a]

	Net outlay		Error[b]	
	Forecast	Actual	Single forecast	Percer
Fiscal year				
1981	$0.16	$1.89	$1 73	91
1982	0 71	2 18	1 47	67
1983	1 80	2.53	0 72	28
1984	0.60	1.50	0 90	60
1985	2.04	2 08	0 04	02
1986	1 37	2.34	0 97	41
Total[d]	**$6.69**	**$12.53**		
Error				
Total				
Absolute (TAE)			5 84	
Mean absolute (MAE)			0 97	
Mean absolute percentage (MAPE)				48
Root mean squared percentage (RMSPE)				53
Bias[e]				
Net (NE)			5 84	
Mean (ME)			0 97	

[a]Dollars are for fiscal years in billions.

[b]Positive errors are underestimates.

[c]Percent errors were computed with exact numbers.

[d]Totals may not add because of rounding

[e]Underestimated 6 of 6 years

In table VI.2, we show a comparison of USDA's dairy budget estimates to a naive model. The naive estimate had a slightly lower absolute error

and a considerably lower net error than the USDA forecast over the 6-year period. This indicates that the USDA error was more biased than the naive forecast. Both forecasts contained large errors.

Table VI.2: Comparison of USDA and Naive Model Dairy Budget Forecasts 1981-86[a]

	USDA			Naive		
	Forecast	Error[b]	Percent	Forecast	Error[b]	Percent
Fiscal year						
1981	$0 16	$1 73		$0 02	$1 87	
1982	0 71	1 47		1 01	1 17	
1983	1 80	0 72		1 89	0 63	
1984	0 60	0 90		2 18	(0 68)	
1985	2 04	0 04		2 53	(0 44)	
1986	1 37	0 97		1 50	0 83	
Total[c]	**$6.69**	**$5.84**		**$9.14**	**$3.39**	
Error						
Total						
Absolute (TAE)		$5 84			$5 63	
Mean absolute (MAE)		0 97			0 94	
Mean absolute percentage (MAPE)			48.5			46 6
Root mean squared percentage (RMPSE)			53.3			50 3
Bias[d]						
Net (NE)		5.84			3 39	
Mean (ME)		0 97			0 57	

[a]Dollars are for fiscal years in billions

[b]Positive errors are underestimates

[c]Totals may not add because of rounding

[d]USDA underestimated 6 of 6 years, naive underestimated 4 of 6 years

The most important component in the dairy budget estimate is the estimate of spending required to support the purchase of surplus dairy products. This component makes up about 93 percent of the error in the dairy budget estimates. The dairy purchase error exhibited an underestimation bias. In fact, the analysts underestimated the dairy purchase spending each year. The average underestimate was $0.91 billion

The dairy product purchase estimate of the interagency commodity estimates committee is arrived at by multiplying the dairy purchase price

by the number of pounds of dairy products estimated for purchase. Th analysts arrive at the estimate of the amount USDA will purchase (calle "net removals") by subtracting the estimated commercial use from the estimated dairy production. We show the error and bias in these key variables in table VI.3. The table shows that the errors in forecasts of production and net removals are biased toward underestimation. Most of the error in the estimate of net removals can be traced directly to th error in forecasting dairy production. The forecasts of commercial use contained a slight bias toward overestimation. This would tend to compound the error of underestimating production, since considerably mor dairy products were produced than expected while somewhat fewer dairy products were used commercially than expected. This resulted in the government's purchasing a larger surplus.

Table VI.3: Total and Bias Error in USDA Key Dairy Variables 1981-86[a]

		Bias		
	Error	Net	Mean	Occurrences in 6 years
Production	30,000	30,000	5,000	Underestimate 6
Commercial use	14,300	(1,700)	(283)	Overestimate 4
Net removals	32,100	32,100	5,350	Underestimate 5

[a]In millions of pounds for fiscal years. Positive errors are underestimates.

Comments From USDA

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

OCT 5 1987

SUBJECT: USDA Review of General Accounting Office (GAO) Draft Report Dated August 18, 1987—"USDA's Commodity Program: Accuracy of Budget Forecasts"

TO: J. Dexter Peach, Assistant Comptroller General
Resources, Community and Economic Development Division
General Accounting Office

Thank you for the opportunity to review and comment on the subject draft report. This letter provides a summary of our general comments and the enclosure provides other detailed information.

Many of the findings presented in the report are valid and many of its recommendations are sound in principle. We are pleased that much of the information and analysis contained in the GAO draft corroborates the results of reviews conducted within the Department of Agriculture (USDA), including the staff working group review mentioned in the report. Thus, we find much in the report of value.

See comment 1.

However, we have identified methodological deficiencies with some elements of the report which, in our view, undermines or limits the basis for some of GAO's findings and conclusions. In addition, there are some gaps and apparent misunderstandings in the report's treatment of the use of the estimates and of the process which produces them. Without some corrections and clarifications, GAO's draft report could well lead other interested parties to draw the wrong conclusions and propose actions that would be unwarranted.

See comment 2.

In addition, we are concerned that a number of fundamental and significant findings and insights contained in the report are not presented in the executive summary. In its present form, the executive summary is very likely to mislead the uninformed reader. We, therefore, believe that the summary should be revised to clarify and qualify many of the statements made.

See comment 1.

The report draws conclusions about the performance of USDA's commodity program estimating process based on limited analysis of the initial estimates prepared for the President's Budget. The process should be evaluated in terms of all its output, including the updated budget estimates. This will show that the process yields more accurate cost estimates as more information on inherently uncertain and unpredictable

variables becomes available. In addition, it should be made clear that the official budget estimates released in the President's Budget in January, and updated for the Mid-Session Review, are not the primary cost estimates used for most commodity program policy decisions. These decisions are made on the basis of the latest supply and demand information available, and the impacts of these decisions are incorporated into subsequent official budget estimates.

We urge GAO to draw on the USDA working group's report and to consult with USDA staff, if needed, to help fill the gaps and otherwise address the points raised in these comments. The working group report entitled CCC Budget Estimates: An Overview and Preliminary Assessment, December 17, 1986 (revised June 8, 1987) was presented to GAO staff in early June. This report, initiated in early 1986, covers many of the same areas as GAO's draft. The two reports together could provide a useful basis for future efforts to evaluate and improve the estimating process. We believe it is in the public interest to make vigorous efforts to maintain a highly professional, technically sound and credible budget estimating capability for the commodity programs in USDA, and we interpret and accept GAO's recommendations as intended to be supportive of that objective. USDA has an elaborate and, we believe, well structured process for developing commodity forecasts and budget estimates for the Commodity Credit Corporation (CCC) programs. The commodity program activity estimates, as well as the policy assumptions and supply/demand forecasts upon which they are based, are documented in extensive detail in the widely circulated CCC Estimates book. However, based on recommendations from both USDA's internal reviews and GAO's review, efforts are underway to improve documentation of factors contributing to changes in the estimates and to clarify responsibilities and to improve coordination for the budget estimating process. Neither USDA's nor GAO's analysis, however, provides any clear evidence that such changes in the estimating process have the potential to measurably improve forecast accuracy. Nevertheless, we believe these changes should be made.

Given the extraordinary degree of uncertainty involved in forecasting agricultural commodity supply/demand and commodity program costs, large forecasting errors are inherently unavoidable. Based on the experience of the several decades that USDA has been in the forecasting business it is not unusual for early forecasts (made long in advance of the actual events), such as used in the initial budget estimates, to exhibit high percentage error rates. This is a reflection of the inherent uncertainties involved (e.g. weather developments and policy changes) and not a result of failure to apply competent staff and procedures to the task. Thus, while we agree with much of the GAO report, it should be understood that even with the adoption of GAO's recommendations as well as USDA initiatives, the budget forecasts would continue to be subject to considerable error as has been the case over the years.

See comment 3

The draft report states that the quality of the forecasting procedures need to be judged through comparison of their performance with that of other procedures. We are not aware of any other organization which has consistently produced more accurate commodity supply/demand and commodity program cost forecasts over the years. The draft report comes to the same conclusion by stating several times that private forecasts have not demonstrated greater accuracy than USDA forecasts. The Congressional Budget Office (CBO) comes closest to forecasting comparable commodity supply and demand and program cost forecasts, and, as pointed out on page 2-23, "any differences between CBO and USDA estimates are typically small." Despite this proven record of reasonable performance when judged by fair standards, maintenance of the credibility of the USDA forecasting process is a continually challenging and delicate task.

Now page 26.

If CCC outlays could be easily and accurately forecast, funding could be achieved through a current, definite appropriation with a pre-established ceiling on the total amount that could be spent in a given year. However, Congress recognized the volatility of the agricultural commodity sector and in forecasting supply and demand and program outlays accurately from the very beginning when it created the CCC in the 1930's with permanent borrowing authority from the Department of the Treasury as the financing mechanism.

We recommend, therefore, that GAO carefully consider these comments as well as the information and suggestions presented in the enclosure. We have also separately provided GAO staff with a marked-up copy of the draft report which includes a number of factual corrections and additional editorial changes and suggestions.

We request that our letter, as well as the enclosure, be cited in the GAO report.

Under Secretary for International
Affairs and Commodity Programs

Enclosure

ENCLOSURE

Review of General Accounting Office (GAO) Draft Report, "USDA's Commodity Program: Accuracy of Budget Forecasts"

The GAO draft report is based on: (1) analysis of the preparation of initial estimates of commodity program costs for inclusion in the President's budget submission, and (2) quantitative analysis of the accuracy of those estimates with the actual results based on only a few years of observation. This approach limits the applicability of conclusions which can be drawn from the analysis. The following sections discuss aspects of these limitations and provide additional information helpful in evaluating and reinterpreting the report's conclusions.

See comment 1.

Relationship of Department of Agriculture (USDA) Budget Estimates and Policy Decisions. Initial budget estimates are not the primary cost estimates used for commodity program policy decisions. The budget estimates are essentially a reflection of the effects of past and anticipated future policy. They, of course, are useful in tracking effects of policy and for fiscal policy purposes. Although Commodity Credit Corporation (CCC) outlays account for roughly two percent of the Federal budget at present, their uncertainty makes them a proportionately greater concern for budget and fiscal policymakers. We also note that because the CCC estimates are so uncertain, rigorous efforts are made to update them during the year. Congressional budget and appropriations decisions often rely on updated estimates.

The accuracy of the initial budget estimates has little to do with the validity or accuracy of the budget outlay estimates made to assist Administration policy officials in choosing among alternative commodity program policies where the ability to identify differences in likely effects of alternatives is crucial. However, we note that GAO found that implementation of program policies different from those assumed in the initial budget estimate was a major source of error (and one not subject to control by the estimators). This, of course, indicates that the estimating process can produce outlay estimates for specific policies which are significantly more accurate than the initial budget estimates where the policy itself was an uncertainty.

Now page 63.

The draft report includes inaccurate information about estimates for program policy decisions. It fails (e.g. page 4-17) to recognize, that although regulatory impact analyses to support Administration decisions usually have estimates of cost differences among alternatives, additional analyses and total cost estimates are also typically made available to decisionmakers.

See comment 4.

The report also appears to be partially in error when it identifies use of different outlay forecasts for budget and for policy analysis as a problem with USDA procedures.

See comment 5.

The executive summary makes a statement to this effect without explanation of the basis for the statement.

See comment 6.
Now pages 68-69.

Pages 4-33 and 4-34 present erroneous information about crop year and fiscal year (FY) data. USDA does develop financial reports

showing actual expenditures by crop year for direct payments, such as deficiency payments, contrary to GAO's statement that no such information is provided. Many of the remaining outlays would be extraordinarily difficult to track on a crop year basis. For example, actual outlays for one year's crop may be affected by next year's program decision, storage costs are hard to sort by crop year, etc. But policymakers do receive significant amounts of information to track whether estimated effects of a given year's program were on target or not (e.g. loan and purchase activity levels, etc.).

It should also be noted that outlay estimates of a proposed crop year's program may include outlays attributable to the effects on transactions involving prior year crops (e.g. loan redemptions). As noted in the report, outlays of a given year's program are often spread over several FYs. It is possible for a relatively accurate estimate to be made of the total outlays of a proposed program policy action for a given crop or program year, but for errors to be made in estimating the proportion of the outlays which will be incurred in each FY affected. This results in larger errors in the budget estimate than in the underlying estimate of program impact.

See comment 1.

Since GAO did not directly review USDA program and policy analysis procedures, the report should clearly state the limited scope of its findings and should reexamine carefully its statements in the summary of Chapter 2 and elsewhere. Few broad inferences made or implied about the quality of information provided for policy decisions can be validly based on analysis of the President's Budget estimates for reasons discussed above.

See comment 3.

Now page 26.

Congressional Budget Office (CBO) Role and Performance. The report also should make clear that the CBO has a primary responsibility to provide commodity program outlay estimates to the Congress, both for budget and program policy purposes. And, as GAO notes on page 2-23, estimates by CBO and USDA have been similar. If CBO's skilled staff had been able to produce substantially better forecasts than USDA, then this would indicate USDA's procedures may be defective. Likewise, if CBO had been able to do significantly better, Congress would not have to be concerned that large errors have been made in USDA's commodity program budget estimates.

Unavoidable Errors and Capability of Estimating Procedures. We believe it essential to try to identify the extent to which the errors may be due to defective estimating procedures. We agree with GAO that this is difficult and that improved documentation and evaluation could be helpful in addressing this question. However, we are concerned that in its report GAO overlooks the implications of evidence regarding this question.

See comment 1

The report does not present analysis of updated budget estimates other than to mention these are more reliable than the initial estimates. Forecast accuracy is significantly improved as more information about uncertain variables becomes available. This evidence suggests that much of the error in initial estimates is due to lack of information about inherently uncertain variables (e.g. program policy, crop yield, export demand, etc.) rather than to defective estimating procedures. The same procedures produce the updates as the initial estimates, the only difference is the increased availability of information about causal variables. Thus, the improved accuracy of the budget updates provide an important indication of the capability of the estimating procedures.

See comment 3

Generalizations Drawn From Inadequate Bases. We believe the report makes some important generalizations which misrepresent and/or overstate the implications of the facts presented regarding performance of the budget estimating process. This includes conclusions regarding implications of USDA's performance in relation to GAO's naive model.

Now pages 39-41.

The report states (on page 3-18) that on "...the basis of a comparison to a simple naive model we developed, we believe USDA's complex budget forecasting process has not been particularly successful." And it also states, "This benchmark forecast generally performed slightly better (less error and less bias) than USDA's forecasts." The report shows only data for FYs 1981-86 to support these statements. Since the other analyses in the report use data from FYs 1972-86, we used GAO's model to compare its results with USDA's for the total 15-year period and found that the GAO benchmark was substantially less accurate in absolute error terms over the 15-year period (i.e., mean absolute percentage error of 97 percent for GAO naive model and 59 percent for USDA). We also compared accuracy over a longer period. According to our calculations the GAO naive model had a mean absolute percentage error of 102.5 percent for the period FYs 1950-86, while USDA had 59.6 percent over that period. On a decade-by-decade basis (1950-59, 1960-69, 1970-79, 1980-86), USDA had a lower absolute error rate than GAO's benchmark in each and every decade. For the period 1980-86 the error percentage was nearly the same, 57 percent for USDA versus 58 percent for GAO. Our computations also showed that both USDA and GAO's benchmark had definite tendencies to underestimate actual net outlays over the years. However, the GAO model did have slightly lower bias measures. GAO's broad generalizations about USDA performance, relative to the naive model, cannot be fully substantiated by a fuller analysis of the data. The initial USDA estimates are generally more accurate, although the GAO benchmark tended to have slightly less tendency to underestimate.

Equally important is the fact that the budget forecasting process cannot be judged only on the basis of the accuracy of initial budget estimates without regard to its performance in updated estimates, as was discussed earlier. The above analysis concerns the quality of the initial President's Budget estimates and not the overall performance of the budget estimating process.

It is imperative, in our view, that GAO limit its conclusions regarding performance relative to the naive model to those which are valid and substantiated by the evidence. Otherwise, readers could be seriously misled regarding the value of the estimating process by such statements as (on page 3-7), regarding the comparison with the naive model benchmark, "...if more sophisticated forecasts including those by USDA are not substantially better, then the quality of the more complex and costly procedure is questionable."

Now pages 33-34.

The report mentions, but does not highlight, the fact that the naive model results confirm that commodity program outlays are hard to accurately estimate and that one reason is that outlays fluctuate significantly from year to year. We believe this to be worth highlighting in the summary of findings. We also suggest GAO present statistical data showing the extraordinary year-to-year fluctuations in the actual program costs and underlying variables being estimated. This would help place the forecasting problem in better perspective. (See the USDA working group's report).

The GAO report's findings could also be placed in better perspective by examining the longer historical record. For example, the mean absolute percentage error was 62.2 percent for the period 1950-71, versus 58.6 percent for the 1972-86 period analyzed by GAO. Clearly, the high percentage errors in the initial estimates are nothing new. There appears to be little, if any, basis for concluding that the performance of the estimating process has significantly declined in recent years. What has happened is that the outlay levels of the programs rose very rapidly during the early 1980's to the current high levels. This larger dollar base times percentage accuracy rates at historically normal levels yields larger actual dollar errors. We note that the draft report's findings for the FY 1972-86 period (pages 3-16 and 5-2) also confirm this.

Now pages 38 and 73.

We also note that page 3-17 of the report states "...there has been consistent growth in the bias over the years." The statement apparently related to dollar levels of "bias" errors during the years GAO analyzed. However, net bias error as a percent of total absolute error appears to have declined slightly during the last five year period (FYs 1982-86) as compared to the preceding five years. We agree, however, that underestimation has been a problem and that net outlays for FYs 1982 and

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1983 in particular were severely underestimated. During that period program net outlays were rising unusually rapidly due to unprecedented and unforeseen declines in export demand and record crop yields. (See USDA working group report, page 36.) The tendency to underestimate outlays more frequently than to overestimate them is a natural result of built-in time lags in the estimating process and the fact that net outlays have tended to go up more often than they have declined. Specifically, when the supply/demand balance is incorrectly estimated for a given year resulting in an underestimate of program costs, then the beginning stocks for the following year are automatically incorrectly estimated since the ending stocks for one year are the beginning stocks for the following year. This results in a likelihood that the supply/demand balance and program costs would be similarly incorrectly estimated for that year as well.

See comment 7.

Commodity Specific Estimates. The draft report includes extensive and potentially useful analysis of the estimates for three commodities—corn, wheat and dairy. However, several technical clarifications are needed to correct some misconceptions about the programs, etc. The results of the sensitivity analyses need to be more discriminating to be most useful. For example, to say that "for dairy, the most important variables were production, commercial use, and net removals..." (page 3-52), is not helpful since in many years there is little else that could affect program costs other than net removals. Further, net removals are for most practical purposes determined by the extent to which production exceeds commercial use.

Now page 57.

Legislative changes can be a particularly significant variable over which budget estimators have no control. In the case of dairy, for example, between March 1981 and December 1985, eight pieces of dairy legislation were passed which added considerable uncertainty to the estimating process. Three major changes were legislated in the milk price support program during the period that the report concentrates on. Each change in the legislation was made after the President's Budget was submitted—two of the three were made after the FY in question began. In each case program outlay estimates were further complicated because the program changes were in effect over more than one FY. Although the total cost of the program could be estimated with a fair degree of accuracy, the allocation to the proper FY was much more difficult.

The timing of each of the above mentioned legislative changes, as a practical matter, made the President's Budget useless with respect to milk price support program outlay forecasts since the legislative basis for the program changed from the time the President's budget was submitted and the conclusion of the following FY in every year since 1981. And, the legislated program changes directly impacted production and use levels. We, therefore, believe that uncertainty associated with the legislative change variable should be given more prominence in the report's discussion of dairy budget analyses.

Summary statements regarding the commodity estimates should, thus, point out the major role of policy and legislative changes as contributors to the errors in some recent years for these commodities (e.g. the PIK programs, as well as the dairy program changes).

Management of Forecasting Process. We would like to clarify a few points regarding the review of management of the forecasting process. The Office of Management and Budget (OMB) has a general oversight responsibility for development of the budget estimates and specifically for the incoporation of estimates into the President's Budget. The Office of Budget and Program Analysis (OBPA) has similar responsibilities in USDA, including general coordination and evaluation of the process. The Agricultural Stabilization and Conservation Service (ASCS) has direct responsibility for developing the CCC budget estimates, including the supply/demand estimates and other inputs actually used in their development. ASCS, however, normally draws on the interagency commodity estimates process to develop the supply/demand estimates for the budget. The World Agricultural Outlook Board (WAOB) has responsibility to oversee the Interagency Commodity Estimates Committees which produce and make available supply/use estimates.

In recent years, at least, quality control has included review of preliminary estimates by OBPA staff, and comparison of selected components with forecasts developed by alternative procedures including models used by the Economic Analysis Staff. USDA forecasters also closely monitor forecasts made by private sector forecasters.

We note that macroeconomic assumptions are much more important for the outyear or longer term forecasts than for the annual budget estimate. The study cited on page 4-8 indicates the importance of these variables in the longer run.

Now page 60.

The discussion of documentation of assumptions and input forecasts, etc. in Chapter 4 seems to overlook the CCC Estimates book prepared by ASCS for each budget estimate and update. It contains highly detailed information on supply/demand estimates, program parameters and other assumptions, and budget estimates for each price support commodity. This book is widely circulated to both Congressional and Administration officials, as well as private sector analysts. To our knowledge, no comparable set of estimates in this level of detail is available for other components of the federal government's budget.

See comment 8.

We believe that GAO inappropriately identified "...changes to program assumptions, such as when deficiency payments will be made, after the estimates are made..." (page 4-39), as a weakness in the forecasting process. Policy changes made by Administration policy officials (or the Congress) increase forecasting uncertainties, but should not be characterized as an analytical weakness.

See comment 9.

Deleted.

Numerous efforts, both formal and informal, are or have been made by USDA to inform users of the uncertainty inherent in budget forecasts. For example, published supply/demand forecasts issued by the WAOB now include data on past error rates. And while formal budget documents are required to utilize point estimates, the USDA agrees that users need to be aware of the limitations of the estimates.

See comment 10

Now page 74.

Point Estimates Versus Ranges. The report's recommendation that USDA develop a range of budget forecasts, as opposed to a single "point" estimate (page 5-5), disregards a number of considerations. First, OMB requires USDA to submit a point estimate, since the official budget cannot accomodate a range of estimates. And, it is extremely difficult to run an accounting system based on ranges or probability distributions. Second, past efforts to develop alternative sets of estimates based on alternative assumptions about underlying supply/demand conditions proved to be costly, time-consuming and of limited value. Third, a range estimate, of course, will not ensure that the budget forecast will be more accurate. Moreover, when range estimates were developed in the past, the actual results were frequently outside the range for the initial estimate contained in the President's Budget. In other cases, the ranges were so wide that they were not very helpful or meaningful to users. Thus, it is difficult to determine the appropriate end points for a range. Ranges based on historical variations can be misleading since program policy and other factors influencing outlay variations have changed substantially over the years. Also, variations among individual commodities interact in ways which make aggregation of component ranges difficult. In conclusion, we agree that there can be a tendency for users to accept point estimates as certain when they are stated in a definitive fashion, but we believe that preparation of a range of formal detailed budget estimates in the aggregate is difficult. However, it may be useful to consider informal forecast ranges for selected commodities based on alternative assumptions or other procedures to develop information on potential variation.

GAO Findings Overlooked in Executive Summary

See comment 2.

Now page 3.

We believe the executive summary and other summary and concluding sections of the report do not fully present the implications of GAO's findings. (We have also commented previously on the inadequate basis for several of the statements in the executive summary.) For example, the report indicates on page XS-2, referring to the total absolute error over the past 15 years, that "76 percent of the error, $48.8 billion, occurred during the 5-year period 1982-86." It fails to mention that 73 percent of the total net outlays also occurred in this 5-year period, which indicates that the dollar size of the error was due to the larger outlay levels and

not to a declining percentage accuracy of the forecasts. The executive summary makes no mention that GAO found no statistically significant differences in forecast accuracy between the 5-year period and earlier periods.

The executive summary fails to mention that the naive model benchmark analysis confirmed the difficulty in making accurate forecasts. It also fails to mention that GAO found no general trends to indicate private commodity analysts make more accurate forecasts than USDA analysts (page 3-53). There are limitations with GAO's comparison of USDA and private commodity forecasts, but it seems appropriate for GAO to identify the results of its extensive analysis of this issue in the executive summary (with appropriate qualifications).

Now page 51.

The executive summary could also be improved by briefly explaining how commodity programs are funded. The CCC borrowing authority mechanism is designed to permit operation of the programs despite the high uncertainty and difficulty in predicting net outlays in advance.

The executive summary conveys little useful information about the results of GAO's analysis of supply/demand variables contributing the most to errors in forecasted outlays for the corn, wheat and dairy programs. It lists almost all the important variables which could affect the forecasts, but it confuses residual variables with underlying causes. It appears that, for the period it analyzed, GAO found the most important variables to be production and exports for corn and wheat, and production for dairy. Policy decisions which differed from assumptions, and legislative changes (especially for dairy, as outlined above), should also be noted as major sources of error in recent years.

Concluding Comments

GAO's draft report and evidence presented in these comments provides substantial evidence that:

- the initial budget outlay forecasts for the commodity programs in recent years have been about as accurate as they have ever been in percentage terms;
- while the USDA forecast error rates are high, no evidence has been found to show that other forecasters have been able to consistently produce better forecasts;
- the forecasts are very difficult to make with any accuracy;
- the budget estimating process produces more accurate forecasts as information becomes available on uncertain factors such as program participation levels, crop yields, etc., which suggests inherent uncertainties rather than defective procedures are the apparent primary cause of the errors in initial estimates.

There are opportunities to tighten procedures, increase analytical input and increase documentation of information useful in evaluation of budget forecasts. There is no evidence, however, that measurable improvements in forecast accuracy are likely to result or are readily achievable. Improvements will be difficult to achieve because of unforeseen developments such as government policy changes and weather related events. GAO's report provides some examples of such events. Efforts to improve management and conduct the forecasting process should be considered to the extent expected benefits are commensurate with the resources expended on such efforts. This is reinforced in the report, which states that the objectives of the forecasting process are "to produce forecasts that are timely, accurate, and appropriate at minimum cost" (page 4-2).

Now page 70.

USDA has commenced implementing some improvements in the process as a result of recommendations made by the USDA working group review, and will continue to search for feasible improvements. Current steps include development of improved documentation of reasons for changes in estimates (from previous estimates). GAO's recommendations will subsequently also be taken into consideration by USDA as we continue to strive to improve the budget process and the accuracy of budget forecasts.

The following are GAO's comments on the October 5, 1987, USDA letter.

GAO Comments

1. USDA commented that the scope of our review was limited because we did not look at the primary forecasts used for program decisions and congressional decisions are often made on updated forecasts and policy analysis. We necessarily had to limit the scope of our evaluation of USDA's forecasting process, which spans several USDA agencies and provides information to policymakers throughout the management cycle of program design, budget formulation, and program execution. After consultation with the Subcommittee's office and with USDA officials, we limited our detailed evaluation to the forecasts made to prepare the president's budget estimate, which USDA recognizes as having primary importance. We have revised the description of the scope of our review in chapter 1 to show that although we concentrated our detailed evaluation on the forecasts used to prepare the president's budget estimate, we also obtained descriptive information about USDA's use of forecasting for program design, budget updates, and policy analysis for implementation decisions.

We believe it is appropriate to emphasize the value of the budget outlay forecasts in the president's budget. The president's budget estimate and the updated budget estimates are USDA's and the administration's estimates of the total cost of a program designed through legislation and through the USDA secretary's implementation decisions on individual provisions for specific commodities. The primary estimates USDA referred to generally deal only with these specific program provisions rather than estimates of the total program. Since the commodity programs are entitlement programs in which costs must be controlled through program design, policymakers need estimates of the total program costs before money can be spent to monitor a program, revise legislation, make implementation decisions, and manage the federal deficit. Further, the revised estimates are not significantly more accurate until 1 year after they have been made and are presented in the president's second budget or 18 months later, in the second midsession review, when little can be done to lower costs. We have shown the error measures for the updates in table 3.3.

USDA's comment that we did not look at the important forecasts ignores the point of our recommendations that USDA improve the management and evaluation of its forecasting processes and incorporate the evaluation techniques we have demonstrated into a structured quality control program. If USDA were to make such improvements, it could evaluate not

only the forecasts used for making the president's budget estimate but also the broader range of forecasts USDA says we should have evaluated. Although we cannot generalize from the results of our analysis to the accuracy of forecasts made for design and implementation decisions, we have developed descriptive information that indicates that USDA's management does not differ by type of forecast and that USDA does not systematically evaluate the forecasts that it says are more accurate.

2. USDA was concerned that we did not include enough qualifying statements in our executive summary. We have added some analysis and clarification to the body of the report and to the executive summary. However, we believe that USDA was asking us to qualify some of our analyses to such an extent that readers would infer that little or no improvement in forecast accuracy is possible. We do not agree that USDA's comments fairly characterize our analyses; our analyses were based on procedures obtained from sources we have cited in the report that have been demonstrated as sound evaluation practices. USDA might adopt these practices in its quality control program.

3. USDA commented that CBO makes comparable budget forecasts for the commodity programs and that USDA's forecast accuracy is about the same as CBO's. USDA also commented that we overstated the value of naive models and that USDA's forecasts are more accurate than those of a naive model if a longer time period is selected. The literature recommends using comparative forecasts in an overall evaluation program in order to raise questions about turning points, bias, and methodology. We believe our analyses demonstrate the value of this technique in USDA's forecasts. The value of comparative forecasts is not diminished when the more sophisticated forecasts are more accurate than or about as accurate as benchmark forecasts.

While CBO's forecasts are not substantially better than USDA's, this does not imply that USDA's procedures cannot be improved, since CBO relies heavily on USDA for many of the program assumptions and supply-and-demand data and since USDA has many more analysts than CBO to develop forecasts. We have revised the report to reflect the time periods we analyzed with the naive model. It is true that over a longer time period, a naive model does not perform as well as USDA's, but the naive model raises legitimate questions about underestimates during 1980-86, when outlays were increasing at dramatic rates.

4. USDA commented that in regulatory impact statements it typically provides decisionmakers with total cost estimates when it publishes estimates of the cost differences of alternatives. This information was not always available in the published regulatory impact statements we reviewed.

5. USDA said that we were in error when we stated that different outlay forecasts are used for budget and for policy analysis. We were referring to the analysts' use of supply-and-demand forecasts that differ from the official USDA supply-and-demand forecasts. We have clarified this point.

6. USDA commented that we presented erroneous information when we stated that USDA cannot compare the forecasts made by crop year with actual outlays shown in the financial statements by fiscal year. Although CCC tracks some direct costs by crop year, it cannot compare the forecasted costs for the commodity programs authorized by the Congress by a crop year to the actual outlays recorded in the financial statements by fiscal year. We presented this information to show the complexity of the process and to show that accurate forecasts by fiscal year are very important, since the Congress does not get forecasted cost by crop year for the total commodity program.

7. USDA commented that our analyses of the variables are useful but should have been made in greater detail. We were demonstrating methodologies to determine the variables, including policy changes, that are critical to the budget error. We made the analyses because other analysts could not definitively tell us what caused the budget underestimates and overestimates. We believe USDA should do more detailed analysis, including sensitivity analysis, which will require better documentation and automation procedures, and these in turn will help in the replication of the forecasting processes.

8. USDA commented that we did not give it credit for the documentation in the CCC estimates book. We have revised the report on this point

9. USDA commented that policy changes should not be identified as a weakness in the forecasting process. We did not identify these changes as an analytical weakness, but identifying the extent to which policy changes contribute to forecast error is a necessary part of evaluation Such analysis also provides valuable information to policymakers on the range of costs associated with alternative implementation strategies

10. In its letter, USDA provided information on its restrictions in using forecast ranges. We continue to believe that policymakers need to know the range of cost that may be incurred, considering the historical error and the alternative implementation strategies. USDA's working group's report also recommends greater use of range estimates.

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Glossary

	The terms relating to the measurements that are used in looking at forecast accuracy are defined in appendix III.
Acreage Reduction	A provision of federal price support programs to control the supply of wheat, rice, feed grain, and cotton by reducing their planting. The acreage to be removed from production is expressed as a percentage of an individual farm's crop acreage base.
Beginning Stocks	The supply or inventory of the farmer-owned reserve stocks, CCC stocks and free stocks of a commodity not used at the end of the previous marketing year.
Deficiency Payment	A direct payment made to a farmer when farm prices are below target levels. It is calculated by subtracting from the target price the loan rate or the national average price of a commodity during the first 5 months of the marketing year, whichever is higher. In general, the government makes deficiency payments to farmers who qualify for the portion of their production that is specified in the farm program.
Diversion Payment	A payment made to a farmer who voluntarily reduces the planted acreage of a program crop and devotes the land to a conservation use. Diversion payments are also made to dairy producers who agree to reduce their milk marketing below a prescribed level.
Ending Stock	The supply or inventory of the farmer-owned reserve stocks, CCC stocks and free stocks of a commodity not used at the end of the marketing year.
Farmer-Owned Reserve	The supply or volume of grain a farmer stores under an agreement with CCC to delay sale for a 3-year period or until the market price reaches a trigger level.
Feed Grain	Any of several grains, such as corn, grain sorghum, oats, and barley, commonly used for livestock or poultry feed. Corn price-support payments generally constitute about 85 percent of total feed-grain support payments.

Loan Participation Rate	The percentage of production that a farmer places under loan. It is based on production from the total acreage enrolled in a program.
Loan Rate	The price per unit (bushel, bale, pound, and so on) at which the government provides loans to farmers to enable them to hold their crops for later sale.
Model	The representation of an object, system, activity, or situation and its elements (or variables) and the relationships between the elements that govern their interaction. The representation may be theoretical, mathematical, or physical or a combination of these.
Nonrecourse Loan	A price support loan to a farmer who can then hold crops for later sale. The loan is called "nonrecourse" because a farmer who cannot profitably sell the commodity and repay the loan upon its maturity delivers the pledged or mortgaged collateral (the commodity on which the loan was advanced) to the government for the settlement of the loan. A farmer may redeem the commodity by paying off the loan and interest. The loan level becomes the support price, because the government becomes an alternative to the market.
Paid Land Diversion	A payment to a farmer who voluntarily diverts acreage out of production. The diverted land must be devoted to USDA-approved conservation practices.
Payment Limitation	A limit set by law on the amount of money any individual may receive in farm program payments each year under the feed grain, wheat, rice, and cotton programs.
Payment-In-Kind Program	A USDA program initiated in 1983 to reduce crop production and commodity surpluses. Commodity producers are eligible to receive commodities in payment for removing acres from production.
Producer Storage Payment	A payment made to a producer for the storage of a commodity in an amount and under conditions that encourage the producer to participate in the program.

Program Participation Rate	The rate at which producers are included in a program. Participation does not necessarily mean a producer will take out a loan.
Regression Model	A forecasting model that relates the dependent variable (such as sales) to one or more independent variables (such as gross national product or the index of economic activity).
Seasonal Average Price	The national average market price of a commodity during the first 5 months of a marketing year.
Set-Aside	A supply control provision of price support programs that requires that a designated percentage of a farm's acreage that is planted in a program crop be devoted to soil-conserving uses (such as grasses, legumes, and small grains that are not allowed to mature).
Supply and Demand	Supply is the total availability of a commodity and consists of beginning stocks, production, and imports. Forecasts for supply are prepared for both U.S. and worldwide production. Demand, also referred to as "use," is the total of the amount exported, the amount used for livestock feed, and the amount used for food products.
Target Price	A price, determined by law, at which farmers can meet the cost of production; sometimes called "guaranteed price level." The target price becomes the income support price. The government bolsters farm income by making deficiency payments to farmers who qualify for them when national average market prices fall below the target. See also Deficiency payment.
Trend Line	A line determined by a set of data points that describes the relationship between time and the dependent variable. In forecasting, the identification of a trend line is based on the belief that, over the short run, future patterns tend to be extensions of past patterns.
Validation	The determination of whether a model or simulation is an accurate representation.

Verification	The determination of whether a computer program correctly performs the manipulations of a model's theoretical or mathematical representation of a real-world entity.
Volume Estimate	The estimated level of activity subject to a specific commodity program provision. Example are the number of bushels of wheat placed under loan and the number of acres to be diverted from production by crop year or marketing year.

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