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# Models And Their Role In GAO



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## FOREWORD

This paper was originally developed to serve as a discussion paper for a special Program Planning Committee (PPC) session on "Models and Their Role in GAO," held on May 24, 1978. At the session, the Program Analysis Division was requested to revise the document and issue it to all GAO professional staff to familiarize them with GAO's previous involvement with models, to present some of the lessons learned from past GAO modeling efforts, and to identify some modeling areas which require further work.

To develop this information, division and office directors, or their representatives, were interviewed. From these discussions, it was obvious that models have played varied roles in GAO reviews and that we can expect an expanded emphasis on them in the future. GAO reviews concerned with auditing and evaluating models from the standpoint of economy, efficiency, and effectiveness did not illicit much concern from management. These roles seemed to follow a natural progression in increasing the comprehensiveness of audits. However, it seems that there is concern with the role of models as an audit tool. This concern may be summarized as follows:

GAO's integrity and its reputation for being accurate are extremely important. In view of this, how much risk is GAO willing to assume by using a planning or policy model to analyze future events and then issue a report based on the model's results?

Specific questions asked by directors on this and other aspects of modeling are contained in Appendix A.

This paper does not contain guidance concerning the use of computer-generated data or the evaluation of computer models. Such guidance is provided in the FGMSD document, "Audit Guide for Assessing Reliability of Computer Output (FGMSD No. 17-S/P, May 1978) and PAD's forthcoming exposure draft "Guidelines for Model Evaluation" (PAD-79-17).

  
Comptroller General  
of the United States

1978

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## CHAPTER 1

### MODELS AND THEIR INCREASED USE

To deal with complex issues in such areas as social welfare, food, energy, the environment, transportation, and urban planning, government policy analysts and decisionmakers are increasingly using models to perform program and policy analyses. What are models? How are they used in GAO? How are they classified? Is there an increased role for models in GAO reviews? These are some of the questions/areas addressed in this chapter.

#### WHAT IS A MODEL?

A model is a simplified representation of the interrelationships among elements of some portion or aspect of reality. For simplicity, this set of elements and their interrelationships may be called a system. This definition is very general and can be applied to many different things, from a toy car to a full-scale prototype of a supersonic aircraft; and from the game of Monopoly, which represents the real estate business in Atlantic City, to a set of mathematical equations that represents the behavior of the national economy.

When it is impractical to manipulate a system itself, a model is generally used to capture the system's key features. However, if all of the system's details were included in the model, the model itself might become too complex to easily manipulate. A model is thus an abstraction of reality which preserves only those features which are the most relevant to its purpose.

#### HOW ARE MODELS CLASSIFIED?

A model may be classified in many ways, including by (1) its intended use, (2) its subject matter, (3) how it handles time, (4) its intended closeness of fit to the outside world, and (5) the techniques used to construct it. The first possibility is best suited for this paper and is discussed below.

Under the first classification method, models can be described as trying to do one (or more) of the following:

- Classify the variables (the data) and show how they relate to each other (descriptive).

--Predict on the basis of these interrelationships how the variables will behave when one or more of them are changed (predictive).

--Determine, given the observed interrelationships of the variables, the best ways of combining or changing them to achieve some desired result (planning).

Some models can be modified to do all three of the above.

The following is a simplified explanation of how these types of models enter into managerial decisionmaking. Consider a corporation whose management wants to know its financial status to borrow money for investment purposes. To demonstrate to prospective lenders the financial condition of the corporation at a given time, management directs the accountant to use the descriptive model "Assets = Liabilities + Net Worth" to develop a balance sheet and earnings statement. This model is developed by classifying and categorizing financial transactions in accordance with generally accepted accounting principles.

Generally, before the lender accepts the information prepared by the accountant, an independent auditor must certify that the financial statements accurately represent the corporation's financial status. The auditor, in accordance with generally accepted auditing standards, states that the data and relationships depicted in the descriptive model are accurate and reasonable. He may do this by taking a representative sample of transactions and analyzing them in detail, so that he can infer that all the corporation's transactions are accurate as represented in the balance sheet and earnings statement and that the two are fair representations of their financial status.

Having the independent auditor's statement, the creditor uses a predictive model to determine the future effects of loaning money to the corporation (i.e., "Will this corporation be able to repay this loan?").

Meanwhile, with the information provided by the descriptive model, the investor is developing a planning model to identify the alternative effects on the balance sheet and earnings statement of investments in stocks, bonds, and/or other interests.

#### THE INCREASED USE OF MODELS IN GAO

The increased use of models in both the executive and legislative branches of the Federal Government stems partly

from advances in computer technology and from the ever increasing need for information by decisionmakers. GAO first used models in the late 1960s when it contracted for the development of a mathematical model to predict, under varying environmental conditions, the water quality of the Merrimack River Basin in New England. In 1971 GAO issued a report which examined selected aspects of computer-oriented war gaming, simulations, and contract studies sponsored by the Department of Defense. The use of modeling within GAO has since grown to include applications in problem solving and decisionmaking in nearly all major issue areas.

Over 40 ongoing assignments involve models in some way and, since January 1976, approximately 70 modeling-related reports have been issued. Generally, these assignments have dealt with models in three different ways:

- Auditing and evaluating an agency's development and use of models (economy and efficiency-oriented).
- Auditing and evaluating a model to determine the reliability of its results (effectiveness-oriented).
- Using and developing models.

## CHAPTER 2

### AUDITING AND EVALUATING AN AGENCY'S

#### DEVELOPMENT AND USE OF MODELS

Reviewing the development and use of models by executive agencies from the standpoint of economy and efficiency clearly falls within the bounds of GAO's responsibility. GAO assignments in this area have ranged from reviews of the model development process in general, to surveys to ascertain the extent of modeling activities in an agency or functional area (e.g., energy, environment) and the ways in which models are used.

There has been congressional interest in GAO's examining some of the broader data and modeling issues at the Federal level. For example, the late Senator Humphrey had asked GAO to study the statistical collection and analysis activities of the executive agencies to determine if these activities contribute to what he felt was the "less than satisfactory information provided policy-makers." Senator Humphrey acknowledged the broad scope of the study and suggested GAO restrict the data areas of concern to "economic and social data as used in policy analysis studies and in other socioeconomic modeling and analysis."

GAO reviews which focused on model development identified a number of recurring problems, including:

- Poor quality and/or lack of documentation made it difficult to understand the model's assumptions, uncertainties, and limitations as well as its capabilities.
- Model development efforts lacked sufficient coordination between the developer and the user. The user did not participate in the planning of the model or in problem definition; thus, the model did not clearly reflect user needs.
- Model development efforts were not adequately monitored.
- Workable provisions for updating the model for future uses were not made; thus, the model soon began to produce outdated information.
- Obtaining data needed to make the model function was not always possible.

These problems prompted GAO to recommend a five phase approach to model development aimed at reducing wasted expenditures for models not used, reducing cost overruns, and initiating model development efforts that will better satisfy demands placed on them. 1/

GAO has surveyed and is surveying the extent to which models are used in the Federal Government. Topic areas range from the 1971 DOD model survey identified earlier, to a survey of models used for food and agriculture policy analysis, 2/ to an ongoing survey of water quality standards and mathematical models. These surveys and other reviews have pointed out that models are used in all facets of Government for descriptive, predictive, and planning purposes. These models address many areas of interest and importance ranging from national policy models to models which analyze very specific issues. For example, models have been used in

- the field of energy to analyze the Nation's alternatives to achieve energy independence and to analyze the technical aspects of synthetic fuel development;
- economics to analyze national economic policies and localize economic issues;
- transportation to analyze the interstate highway system and to develop integrated transportation plans for metropolitan areas;
- health, education, and welfare to analyze alternative national welfare reform measures and to develop inventory control for a city's blood bank;
- the environment area to analyze the interactions of many factors affecting the total environment and to analyze water quality in individual rivers; and
- the food and agriculture area to predict the level of world grain reserves, to make national and inter-regional agricultural projections, and even to predict the price of eggs.

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1/"Ways to Improve Management of Federally Funded Computerized Models," (LCD-75-111).

2/"Food and Agriculture Models for Policy Analysis," (CED-77-87).

## CHAPTER 3

### AUDITING AND EVALUATING A MODEL TO DETERMINE THE RELIABILITY OF ITS RESULTS

Reviewing the effectiveness of a model used by an agency is clearly within GAO's responsibility. To date, three divisions have completed work in this area and several ongoing assignments have been identified. GAO's work in this area has ranged from auditing models which support tactical and strategic weapon systems development to evaluating models used for policy analysis in social programs.

Models are used to support arguments in agency analyses, policy papers, and expert testimony. They have impacted on policy studies and public editorials--to say nothing of their routine use in forecasting services and agency operations. All too often, answers are not available to basic questions such as, "How much confidence can I (the decisionmaker) place in the results provided by the model?". As more complex models are being developed and used by many units of the Federal Government, there is a need to evaluate these models to objectively assess their capabilities, to help guard against their inappropriate use (either intentional or unintentional), and to promote the increased use of models in a proper setting so that the decisionmaker can have greater confidence in the model's results.

Some policy models, such as the Project Independence Evaluation System (PIES), have attracted considerable publicity. PIES was used by the Federal Energy Administration to support the Project Independence effort, whereby the effect of alternative policies on the supply, demand, and price of all forms of energy in the United States was assessed. GAO received a congressional request from the Science and Technology Committee to review PIES. <sup>1/</sup> The intent of the request, as expressed by a committee staff member, was to determine the "rough level of confidence" which could be placed in the model's results.

Further, the need for a capability to audit models and agency activities in this area was established by the Energy Conservation Act which states that:

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<sup>1/</sup>"Review of the 1974 Project Independence Evaluation System (PIES)," (OPA-76-20, April 21, 1976).

The procedures and methodology of the Office of Energy Information and Analysis (FEA office responsible for PIES) shall be subject to a thorough annual performance audit review. Such review shall be conducted by a Professional Audit Review Team which shall prepare a report describing its investigation and reporting its findings to the President and to the Congress... the Chairman of the Professional Audit Review Team shall be designated by the Comptroller General. (P.L. 94-385 Part B, Sec. 55 (a))

The first report which fulfilled this requirement was issued in December 1977 and describes actions needed to improve the credibility of energy models and data. 1/

The task of auditing and evaluating models used by agencies is hampered by the lack of generally accepted guidelines. The Program Analysis Division is in the process of issuing an exposure draft report concerning guidelines for model evaluation. Additionally, the Financial and General Management Studies Division (FGMSD) has developed guidelines to assess the reliability of computer output. 2/

However, in evaluating/auditing a model, it is very important to recognize that a model must not be judged only in the abstract against certain ideal goals. Consideration must be given also to its purpose and objectives, the way it is being used, and other feasible alternative approaches which might be used to solve the problem. Anyone evaluating a model should bear these thoughts in mind.

The criteria for model evaluation developed by the Program Analysis Division (PAD) and pertinent questions which address these criteria are given below:

#### Documentation

--Is the model's documentation written so that the user/decisionmaker can understand, use, and maintain the model?

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1/"Activities of the Office of Energy Information and Analyses," Dec. 5, 1977.

2/"Audit Guide for Assessing the Reliability of Computer Output," May 1978.

### Verification

--Has the model been adequately tested to ensure that it behaves as the developer intended?

### Validity

--What theoretical assumptions are made in developing the model; how accurate, impartial, and appropriate are the data used in the model; and, what effect does the use of these assumptions and data have on the model's results?

### Maintainability

--Have adequate procedures been established to maintain the model over its life cycle?

### Usability

--Is the model usable by policy analysts/decision-makers?

These criteria are interrelated and they impact on one another, therefore, they need to be considered concurrently. Also, some criteria will assume greater importance than others for a particular model evaluation. The exact mix or blend will depend upon such factors as the importance of the process the model was developed to simulate and the evaluator's experience and perception of that process. For example, the model may have been evaluated by another interested party. Such an evaluation might enable the present effort to focus attention on previously identified weaknesses in the model. Or, a good evaluation of another model developed for the same purpose may have been completed; this might permit a comparison of the two models.

Model evaluation is not a straightforward process. Indeed, model evaluation is in its infancy and is currently, more an art than a science.

## CHAPTER 4

### THE USE AND DEVELOPMENT OF MODELS WITHIN GAO

Although GAO has experience in developing and using models, this role poses some concern for GAO. This is because, as we previously stated, GAO's integrity and reputation for being accurate may be at stake if models are not used judiciously and carefully. However, because of increased demand by Congress in this area and because of more complex audits there is no question that GAO is going to be asked to do more reviews using models.

Recently, models were developed at GAO to:

- Evaluate how the Navy's spare engine support system for the F-14 engine would behave using GAO's stock level proposal. 1/
- Review proposed Veterans Administration and military hospital construction projects. 2/
- Evaluate the effect of antirecession assistance of Title II of the Public Works Employment Act of 1976 in stimulating the economy during a downturn. 3/

In addition to developing models, GAO reviews have often used models developed by others to:

- Determine the potential impact on trade of increased taxation of U.S. citizens employed overseas. 4/
- Predict the probability that individuals will not file income tax returns.

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1/"Alternatives Available for Reducing Requirements for Spare Aircraft Engines," (LCD-77-418, October 12, 1977).

2/"Inappropriate Number of Acute Care Beds Planned for VA for New Hospitals," (HRD-78-102, May 17, 1978). See also HRD-78-51, February 6, 1978; HRD-77-104, May 20, 1977; and MWD-76-117, April 7, 1976.

3/"Antirecession Assistance--An Evaluation," (PAD-78-20, Nov. 29, 1977).

4/"Impact on Trade of Changes in Taxation of U.S. Citizens Employed Overseas," (ID-78-13, Feb. 21, 1978).

In particular, GAO's use of large, commercially available econometric models, has grown. The first commercial, econometric model was developed by Data Resources, Inc. (DRI) in the late 1960s. GAO began using econometric models about this same time and over the years has increased its modeling activity. In fiscal year 1977, GAO spent over \$70,000 to use seven different models, and the fiscal year 1978 budget includes over \$200,000 to use five different econometric modeling services. The figures for 1977 and 1978 do not represent the total GAO effort in modeling. The Office often receives free access to models in other agencies and in Congress and there is "modeling money" included in ADP budgets and expenditures.

However, GAO's use of large scale policy models dealing with social issues, such as the PIES model, has been minimal. These models, which are generally more complex and which are designed for longer-term planning, inherently produce more uncertain results. It is also generally agreed that models dealing with social issues entail more uncertainty and risk than models dealing with physical or natural phenomena. It follows that greater caution should be exercised when using the results from models dealing with social issues, particularly in trying to judge, as accurately as possible, just how much confidence one can put in the results obtained from these models.

Since using a model may be likened to using a consultant/expert, we should keep in mind GAO's recently revised policy for using expert assistance, which states: 1/

#### Use of expert assistance

In situations where highly technical matters are to be evaluated, we should first consider using the services of GAO staff members who have special technical expertise. A technical assistance group in the Financial and General Management Studies Division is staffed to provide expert advisory services in accounting and other financial management matters and in the fields of automatic data processing, systems analysis, actuarial science, and statistical sampling.

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1/Comprehensive Audit Manual I, Chapter 8, pp. 6-8.

If our work involves technical matters on which we do not have the in-house capability needed to express authoritative opinions, we should ask the agency to review and test their procedures in ascertaining compliance. Under some circumstances it may be desirable for us to obtain the cooperation and assistance of technical experts of the agency whose program or activity we are examining. In others we might prefer to obtain an independent check through technical assistance obtained directly by us (e.g., outside laboratories, the National Bureau of Standards, or other appropriate Government agencies).

The complex and technical nature of some audits may make it necessary for us to use outside experts and consultants to assist our own specialists in reviewing specific problems. However, it is not enough simply to give a consultant a task to perform. We should monitor what is done and how it is done and do everything necessary to satisfy ourselves that we and the consultants fully understand and agree on the scope and objectives of the work.

The extent of our day-to-day involvement with experts and consultants in the performance of their work can vary. In most instances, it will be advantageous to assign staff to work with them or to monitor their activities and discuss problems with them. In other instances, the nature of the work may be such that limited involvement and discussions will be adequate.

The objectives of our involvement are to (1) understand the nature of their work, the significant assumptions they have made, the reasoning underlying their analytical choices, and the risks inherent in their data and analysis; (2) make suggestions to them so that their work will be of most benefit to us; and (3) satisfy ourselves that the work being done conforms to what we intended.

We should determine early how important the work of experts and consultants is in relation to the total assignment and how we intend to use the results of their work. If we decide to use information developed by them in our report, we should, to the extent practicable, require that they furnish us sufficient supporting documentation so that we can independently satisfy ourselves as to its accuracy and validity.

In addition, we should advise consultants and experts of our reporting policies concerning their work as stated in Chapter 5 of the Report Manual.

In conclusion, subsequent to the PPC session, Mr. Staats issued a memorandum which establishes FGMSD as the primary source of assistance in the review or use of models in GAO (see Appendix D). PAD and FGMSD currently are working together to identify the training needs of GAO staff in the modeling area.

PAD RESPONSES TO QUESTIONS RAISED BY DIVISION DIRECTORS

The answers provided in this appendix are directed towards the predictive and planning models described in Chapter 1. Some examples of these models are PIES, the Strategic Environmental Assessment System (SEAS), the Transfer Income Model (TRIM), and the Mesarovic-Pestel World Model.

I. Questions relating to auditing and evaluating an agency's use of models

1. What controls and guidance are needed while models are used? (This question is also appropriate for using models as an audit tool.)

Controls and guidance for the use of models are necessary to ensure the user of the model's credibility. Therefore, it is important that there be controls throughout the modeling process from determining the need for a model, through the development of a model, to the model's use and updating. These controls may take the form of budgetary constraints as well as direct management oversight to ensure that the models are being used efficiently and are being applied to problems that need this type of analysis. Other controls, such as documentation and independent checks on the results of the model, should be developed. Also, guidelines should be developed for the use of the model. Further, GAO has previously recommended that the Department of Commerce formulate standards and that the General Services Administration develop and provide guidance for improving Federal agencies' management of computerized models. ("Ways to Improve Management of Federally Funded Computerized Models," LCD-75-111, Aug. 23, 1976).

2. Who should control an agency's use of a model?

This is not for us to say. It will depend upon the agency and its function and relation to other agencies, the purpose of the model (e.g., internal/external use for prediction/planning), the size of the model, the cost to run it and analyze its results, the uncertainty of the results, and the risk associated with this uncertainty.

3. Does the cost of the model justify the results obtained from using it?

This question should be asked at the beginning of any modeling effort. It is the classical cost vs. benefits question and attempts to answer it should be made. Factors that should be considered are what alternatives exist and what costs, benefits, and risks are associated with them versus the proposed modeling effort. Obviously, the answer to the question must be made on a case-by-case basis.

4. How can effective dialogue between model users and designers be established?

The decisionmaker/user or his representative, along with the developer/analyst, should be closely involved with the project from its initiation to its completion. Such involvement will help to ensure that the decisionmaker's desires are appropriately incorporated into the model. Methods to facilitate an interchange can include adequate documentation of the conceptual basis of the model, its assumptions and limitations; the involvement of an intermediary or "policy analyst;" and improvement in the form in which results are presented.

5. Should models be used if they increase the efficiency of the job?

All other things being equal, and assuming the cost of the model is not prohibitive, the answer is yes. The overriding consideration should be if you can do a better job with a model than without one, then, by all means, use the model.

## II. Questions primarily concerned with auditing and evaluating a model

1. How is the validity of a model determined?

Since a model is an abstraction of reality and is often regarded as a substitute for the real system it represents, a major factor in determining its validity is to identify how closely the model mirrors reality. The process used to test the agreement between the conceptual model and the real system it represents is generally called "validation." A model is often referred to as having been validated-implying a procedure that can establish the truth or falsity of the model.

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model to simulate past history (i.e., use 1974 data and assumptions to estimate 1977 conditions and compare to 1977 known conditions).

3. How is the model's credibility established?

There are no generally accepted guidelines for establishing a model's credibility. In addition, there is not a generally accepted threshold beyond which a model can be termed "credible." The concept of credibility varies greatly between model builders/developers and users/decisionmakers as well as among individuals within either of these two broad groups. The following discussion describes a procedure which can be used to establish the credibility of a model acceptable to both model builder/developers and model users/decisionmakers. This procedure deals with documentation, verification, and validation of the model and to a lesser extent with the credibility of the model developer.

To establish the credibility of a model, the process that created it should be documented and the model should be tested. As an absolute minimum such documentation must include the intended purpose of the model, the key assumptions made, a discussion of the reasonableness of these assumptions, and the basic structure of the model. Naturally, the more complex a model is, the more supporting documentation will be required. As complexity or comprehensiveness increases, it also becomes necessary for the developer to explain why any seemingly relevant variables or effects have been omitted from the model. Of course, the entire modeling effort is a long, involved process which usually requires many adjustments to the initial "model" before the developer is satisfied. Thus, documentation should include a clear, concise summary of why the present form of the model is a reasonable representation of reality for its intended use. More comprehensive documentation would include a discussion of the range of applicability of the model.

Model documentation is the principal method by which those interested in a modeling effort, --the user, the model developer, potential users, evaluators, etc.--can communicate. Complete documentation is important to (1) ensure that the model

is thoroughly understood and can be operated and maintained in the present and the future and, (2) facilitate evaluation of the model by a third party (i.e., someone other than the model developer or initial user). Credibility cannot be established if the model documentation is not sufficient for a third party to understand and use the model.

If the model is programmed for and used on a computer another source of error is added since the computer program is yet another level of abstraction beyond the conceptual model. The process used to test the agreement between the computerized model and the conceptual model is generally called "verification." Some of the many tests/questions that exist to establish confidence in the verification process are:

- Are the variables and relationships of the conceptual model accurately represented by the coding in the computer program?
- Have acceptable management, computer system, and program controls been established for the execution of the program?
- Have acceptable debugging procedures been used?

FGMSD has been working in this area for some time and has produced several documents which provide a more comprehensive guide to assessing computer models and programs. Some of these documents are:

- "Auditing a Computer Model: A Case Study" (May 1973)
- "Guide for Reliability Assessment of Controls in Computerized Systems - Financial Statement Audits" (Exposure Draft, May 1976)
- "Guide for Evaluating Automated Systems" (Exposure Draft, March 1977)
- "Guide for Reliability Assessment of Computer Processed Data" (May 1978)

Model validation, as discussed in the preceding question, is a process of assessing a model's structure, data, and controls according to specific

criteria or standards which are deemed desirable. This process leads to a level of confidence about the model or an assessment of the model's strengths and limitations. The validation process generally focuses on the model's assumptions and tries to test their effect on the model's ability to make statements about reality.

Tests/questions which can be applied in establishing the credibility of the developer and of the model are:

- What is the "track record" of the model?  
(i.e., how has the model performed in explaining or predicting the events it was intended to analyze?)
- What are the credentials (i.e., knowledge, experience and track record) of the model's developer(s)?
- What pressures exist on the organizational unit responsible for operating, maintaining, and/or modifying the model?
- What are the results of assessments of the model made by those who were independent of its development?
- Have the results of the model been compared judgmentally to the results of another model developed for the same or similar purpose?

This list is not all inclusive, but is meant to illustrate the types of tests/questions needed to establish the credibility of a model and its developer(s). The process, of necessity, is a very subjective one since objective measures for each of the tests currently do not exist. Recognizing this, the following is suggested as a procedure to communicate information concerning a model's credibility and applicability:

1. State the purpose for which the model has been built.
2. Document the conceptual model and the computerized model.

3. Specify

--the domain of applicability (e.g., the prescribed conditions for which the computerized model has been compared against reality and judged suitable for use) and

--the range of accuracy (e.g., demonstrated agreement between the computerized model and reality within a stipulated domain of applicability) and relate these to the purpose for which the model is intended.

4. Verify and validate the model using appropriate tests and discuss the model's strengths and limitations.

4. How many resources should be expended in evaluating a model prior to its use?

As in any evaluative effort, cost vs. benefits or risks of the effort must be given adequate thought. The amount of effort expended on a model evaluation must be commensurate with the estimated benefits or risks. The degree of evaluation needed will depend upon such factors as the level of decisionmaking the model impacts, the purpose of the model, the costs to develop and execute the model, and the degree to which the model may be used by others.

The GAO standards of evidence (CAM I, p. 9-4) - sufficiency, competence, and relevance - are all represented in the tests suggested in questions 1 through 3. These tests can be used to generate information upon which a judgment of risk can be made - but it is a judgment. The more complex the model is, the more it relies on theory which is subject to debate (e.g., social science). Also, the further into the future the model is being used to forecast, the less certain the model's results become, and consequently the risk of inaccurate results is greater.

The importance of the model results must also be considered when determining the resources to expend in evaluating a model. For example, a model whose results are to be used as background information might warrant less evaluation than a model whose results are to be used to support a finding or recommendation.

5. How is a model's effectiveness evaluated? How are models used effectively?

Models are evaluated, like anything else, by appropriate criteria. One method used to evaluate a model's effectiveness is contained in our recent report on the Transfer Income Model (TRIM), (PAD-78-14). What are the major assumptions made in the model; is the documentation written so that the user/decisionmaker can understand, use, and maintain the model; and is the model usable by policy analysts/decisionmakers; are some questions the TRIM report addressed. Additionally, effectiveness can be determined by how well the model describes or predicts events.

Models may be said to be used effectively when used by decisionmakers for their intended purpose. To be sure that the model is being used as intended would require some sort of initial evaluation which may be very costly in terms of time, money, and staff. However, to use a model without some sort of reasonable, substantive analysis/evaluation is unwise.

### III. Questions relating to the use and development of models within GAO

1. What qualifications are necessary when reporting results based on a model?

The type of model used and its general characteristics should be specified in the report. Further, the workpapers should at a minimum identify the assumptions underlying the model, important implications which can be derived from these assumptions, and the results of the model, etc. There should also be an indication of how, when, where, etc., the assumptions differ from perceived reality and give reasons why it is believed these differences are insignificant for purposes of the present analysis. Naturally, the availability of this information presupposes that the model has been evaluated appropriately, but, in our opinion, this is an essential step which must be completed before a model is used by GAO. Otherwise, the validity and credibility of GAO statements based on the model are questionable. Additional comments on this are given in Chapter 4 and in CAM I under use of expert assistance (pp. 8.6 through 8.8).

2. How can GAO's use of a model be communicated to others?

In some instances, GAO's use of a model might be relegated to a report's technical appendix or it may be part of a report's body. For some novel applications, a staff study approach might be best, but the use of a model should not cause abnormal changes to the GAO product. In any event, the end product should contain the information discussed in question 5, p.20 in clear, concise language. Additionally, as GAO uses models, it is likely that close, professional communication would develop between GAO modelers and persons using the same model or similar types of models.

3. If we use a model developed by someone else, are we not incorporating the biases of the developer with our analysis?

All analytic models have some type of bias. This is the principal reason why we emphasize evaluating the model prior to its use. However, if we use a model developed by someone else, we would not necessarily incorporate the biases of the developer in the GAO analysis. The model should be judged on its own merits and its ability to answer certain types of questions. In this manner, we can probably identify any biases, whether embedded in the assumptions or the underlying methodology, and address them in any study using the model. If a model was found to contain many of the developer's biases, an explanation of how these biases affect the model's results must be given.

4. What levels of controls are needed when deciding to use a specific model?

When deciding to use a specific model, certain controls such as (1) determining whether this model is appropriate to address the problem, (2) determining the cost to use the model, and (3) determining the resources necessary (in time, money, and personnel) to use the model, should be maintained. Additionally, if we consider the use of a model to be the same as the use of expert assistance, there are certain controls specified in the CAM, Part I, and which have also been identified in Chapter 4. Lastly, if a model, particularly

a large-scale model, is to be developed for a specific use, there are additional controls/factors to consider. These are discussed in more detail in question 3, p. 16 and in the report, "Ways to Improve Management of Federally Funded Computerized Models" (LCD-75-111, 8-23-76).

5. How do we determine when to use a model?

First observe that models are used all the time, often unconsciously. Anytime the behavior of a system is estimated, a model of some kind is being used. Determining when to use a model is similar to determining when to use a consultant, and, as we have already pointed out, there is a procedure for use of expert assistance (See CAM, Part I or Chapter 4 of this paper).

Also, whether to use an existing model whose structure, behavior, and ability to give reasonable answers, etc. are known, whether to develop a new, perhaps more comprehensive or perhaps simpler model should be considered along with determining when to use a model. This basically is a cost/effectiveness question (i.e., these are two alternatives) which must be addressed on an individual basis. Many times in the past, managers have relearned the lesson that it would have been cheaper to develop a new model than it was to learn how to use an existing model appropriately, and vice-versa. A factor which should be included when answering this question is the institutional learning which can accrue through the development of a model.

The use of an existing model, of course, depends on the ability to transfer the model. Factors involved here are suitable facilities (i.e., computer systems, hardware or software), staff technical capabilities, adequate documentation, and technical support from the developers, as well as institutional compatibility.

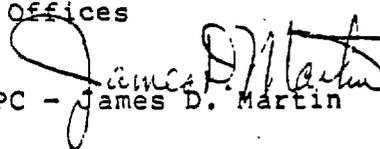
UNITED STATES GOVERNMENT

GENERAL ACCOUNTING OFFICE

*Memorandum*

June 19, 1978

TO : Program Planning Committee  
 Heads of Divisions and Offices  
 Regional Managers

FROM : Executive Secretary, PPC -  James D. Martin

SUBJECT: Special PPC Session on the Role  
 of Models in GAO Review  
 (PPC-78-16, 5/24/78)

A summary description of the session and decisions reached as a result of it follow.

PURPOSE

To discuss several possible functions or activities related to modeling and the possible assignment of responsibility for them to GAO divisions and offices.

CONCLUSIONS REACHED/  
ACTIONS TAKEN OR PLANNED

--There are two basic approaches to how GAO can deal with models as analytical tools both as users and evaluators: (1) develop the necessary expertise in each division, or (2) concentrate the expertise in a single division which serves as the Office's consultant on model use and evaluation. At present both PAD and FGMSD have some modeling expertise and have assisted other divisions. Other divisions, such as CED and PSAD, have also used and evaluated models. Thus, the Office has been taking a hybrid approach to models--two divisions have developed considerable expertise and are assisting other divisions, some of whom are developing experts of their own.

--FGMSD and PAD will prepare a paper outlining what modeling assistance each presently offers and what each would provide in the future. However, FGMSD/TAG will be considered the primary source of modeling assistance for other divisions.

--In many ways, GAO's experience with models mirrors its automatic data processing experience. This is quite evident in the training area--some training in models is necessary for most of our staff. FGMSD and PAD will collaborate on an assessment of the Office's overall modeling capabilities and training needs. This assessment--which will be used for budget decision making--should identify the courses available from outside sources. ..

—PAD's March "think paper" issued will, with some refinement, serve as a valuable part of our training process. PAD and OPP will refine the document and disseminate it to GAO staff.

Approved:



ACTING Comptroller General  
of the United States

cc: Issue Area  
coordinators

UNITED STATES GOVERNMENT

GENERAL ACCOUNTING OFFICE

*Memorandum*

JUL 28 1978

TO : Director, OPP

FROM : Director, FGMSD /S/  
Director, PAD (Signed) Harry S. Havens

SUBJECT: Modeling Assistance - Your memorandum of 6/19/78

This memorandum is in response to the special PCC session on the role of models in GAO reviews. At that meeting it was agreed that FGMSD and PAD would prepare a paper outlining what modeling assistance each presently offers and what each would provide in the future.

Current Assistance

PAD has used large macro-economic models, such as the Wharton, Chase and DRI econometric models of the U.S. economy, to a much greater extent than has FGMSD. PAD has also reviewed in some detail the Transfer Income Model (TRIM) and the Project Independence Energy Systems (PIES) models. Again these are quite large models. The large macro-economic models have been used primarily in PAD's own reviews, but have also been used to provide assistance to other divisions, e.g., to ID in its review of taxation of Americans overseas. TRIM was used to provide assistance to HRD, specifically to their task force on alternative income distribution systems.

FGMSD's experience has, for the most part, been with smaller models. FGMSD's Technical Assistance Group (TAG) has reviewed agency models on some assignments and has developed its own models for others. All the models FGMSD has built have been relatively small. Examples of agency models reviewed or currently being reviewed by FGMSD/TAG include: (1) the IRS model used in selecting individual tax returns for audit; (2) the model used to compute heating oil index prices (i.e., the price that would be in effect had price control continued); (3) the CONRAIL model used to forecast revenue and costs; and (4) GSA's inventory method of supply model.

Examples of models FGMSD/TAG has built include models to (1) compute the airline costs that would have existed had air fares been deregulated; (2) forecast Postal Service volumes, revenue, and costs; (3) select welfare cases for recertification review, (4) measure the benefits of auto safety standards, (5) assess the economic effect of federally connected children and school districts, and (6) determine the cost-effectiveness of two military physician procurement programs.

#### Future Assistance

We recommend that FGMSD have the lead role in providing modeling assistance to the other divisions consistent with its overall technical assistance role, i.e., the other divisions should be instructed to contact FGMSD/TAG for modeling assistance. TAG could then determine whether it could handle the assist or refer the requestor to PAD.

To the extent necessary to achieve audit objectives, FGMSD will (1) review and comment on agency models (of a smaller scale than TRIM), and modify them as necessary, and (2) develop, when necessary models such as those mentioned above. On those assignments where FGMSD determines that macro-economic models (or any other models that PAD has expertise in) could provide the needed answers, FGMSD will contact PAD to arrange for its assistance. (FGMSD currently has limited expertise with one of the macro-economic models). If a continuing demand develops for operating these models on behalf of other divisions (other than in connection with PAD's general economic assistance work), FGMSD will develop the needed skills to relieve PAD of the burden of running the models as direct assistance to the other divisions.

Finally, other divisions should not be discouraged from using the modeling expertise that exists within their own divisions. For example, PSAD staff should continue to go to PSAD's Systems Analysis staff for assistance on war games and other weapons-type models. However, we believe they should not at this time be encouraged to hire new staff members to do modeling work unless a well-defined, continuing need exists.

UNITED STATES GOVERNMENT

GENERAL ACCOUNTING OFFICE

*Memorandum*

August 7, 1978

TO : Heads of Divisions and Offices  
Regional Managers

FROM : Comptroller General *R. A. [Signature]*

SUBJECT: Source of Assistance in Reviewing  
or Using Models

Several of GAO's divisions have either reviewed models or used models in reviews of agency programs. As our experience has grown, there has been some confusion as to which division, if any, could be looked to for office-wide assistance.

At the request of the Program Planning Committee, PAD and FGMSD analyzed various modeling needs of the Office, and recommended that FGMSD be the primary source of modeling assistance in GAO. I agree with that recommendation. The Technical Assistance Group of FGMSD should be contacted whenever any division needs assistance in reviewing or developing models. If FGMSD believes that the requested assistance requires expertise which PAD has, the requestor will be referred to or FGMSD will arrange for assistance from PAD. Where the use of one of PAD's large econometric models is incidental to assistance in economic analysis being provided by PAD, the FGMSD contact is, of course, unnecessary.

While this arrangement establishes a single point-of-contact for modeling assistance, it does not preclude other divisions from developing modeling expertise on their own. However, divisions other than PAD and FGMSD are not authorized to establish modeling groups or staffs, nor are they encouraged to hire new staff members to do modeling work unless a well-defined, continuing need can be demonstrated to the Program Planning Committee.