CHAPTER 4

# Global Models and Government Foresight

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## Introduction

The "futures debate" of the last 15 years has taken place against a background of rapid and sometimes unexpected changes in national and world affairs, including:

- a general slowdown in the rapid economic growth that had characterized the world economy since World War II, leading to stagnation in the industrialized nations and stalled development in the less developed countries (LDCs);
- rapid population growth and urbanization in much of the Third World, leading in some cases to widespread hunger, social unrest, and political instability;
- structural changes in the world's political and economic systems, typified by the emergence of OPEC and new nuclear powers and by Third World demands for a "new international economic order;"
- growing apprehension about the cost and continued availability of natural resources, best exemplified by the energy crisis; and
- increasing concern for the regional and global environmental consequences of continued industrialization.

These and similar developments have shown that long-term global trends can have serious implications for the economic and national security interests of the United States. This in turn has led to proposals in Congress and elsewhere that the U.S. Government should improve its "foresight capability ''—its institutional capacity to project long-range global trends and their consequences, and to use these projections as inputs in the process of strategic assessment, policy development, and decisionmaking. A number of Federal agencies are already using global models and other computerized models as tools of long-range analysis and planning, but the Government's present capability is limited by unevenness of data, inconsistency of assumptions, and lack of proper coordination. * If existing deficiencies are corrected, global models could become a more effective tool in four specific areas:

- assessing the potential future impacts of current trends, policies, and decisions;
- monitoring the national and international situation to identify early signs of potential problems or opportunities;
- formulating and evaluating a wide range of alternative policies and courses of action for achieving national goals, avoiding potential problems, and exploiting potential opportunities; and
- providing a framework to ensure consistency between short- and long-term analyses and across agency jurisdictions.

[1]For specific details, see the discussion of the *Global 2000 Study* in ch. 2 and the appendixes. Examples of previous Government uses of models and comparisons with traditional long-range analytic and planning techniques can be found in the following sources:

- *A Guide to Models in Government Planning and Operations* (Washington, D.C.: U.S. Environmental Protection Agency, 1974);
- *Federally Supported Mathematical Models: Survey and Analysis* (Washington, D.C.: National Science Foundation, 1974);
- *Computer Simulation Methods to Aid National Growth Policy*, prepared for the Subcommittee on Fisheries, Wildlife Conservation, and the Environment of the House Committee on Merchant Marine and Fisheries (Washington, D.C.: Library of Congress, Congressional Research Service, July 1975);
- *Long-Range Planning*, prepared for the Subcommittee on the Environment and the Atmosphere of the House Committee on Science and Technology (Washington, D.C.: Library of Congress, Congressional Research Service, May 1976);
- Joint Economic Committee, *U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns*, 12 vols. (Washington, D.C.: U.S. Congress, 1976-77), especially vol. 2, *The Factors and Processes Shaping Long-Run Economic Growth*, vol. 6, *Forecasts of Long-Run Economic Growth*, and vol. 7., *The Limits to Growth*; and
- *The Use of Models for Water Resource Management, Planning, and Policy* (Washington, D.C.: U.S. Congress, Office of Technology Assessment, forthcoming).

# Benefits of Global Models

The essential claim for global models is that they represent the behavior of the real global system, or at least some of its components, in ways that are superior to the less formal mental models and forecasting techniques currently being used by decisionmakers, policy analysts, and the general public.[2] Their benefits are those of mathematical models in general and computerized models in particular, the difference being that global models are specifically designed to address problems and issues of a global scale and importance. This can make them a valuable tool of analysis and a valuable additional input to policy development and decisionmaking. Specific benefits of global models include the following.[3]

- Longer time horizon.—Many current forecasting techniques are used primarily for annual or short-term projections, whereas global models typically have time horizons of 20 years or more. This allows them to assess long-term effects and cumulative changes, however critical, that might not otherwise be detected.
- Comprehensiveness.—A computerized model can contain far more information about the world system than any single mental model. It can also keep track of many more variables and interrelations at the same time and, according to some modelers, it is far more sensitive to subtle, remote, or counterintuitive effects and outcomes.
- Rigor.—They impose a logical discipline by requiring the modelers—and the model users—to make explicit, precise, and complete statements of their objectives, assumptions, and procedures. The system or process being modeled must be clearly divided into its major components, and the relations between those components must be specified. This procedure may lead modelers and model users to revise their mental models—or to refine them by identifying previously ignored components and relations—even before computer analysis begins.
- Accessibility.-The assumptions and structure of the model must be written out before they can be run on the computer. This allows all sides to examine them, point out omissions or inconsistencies, and suggest improvements. Open communication about both the system and the model can lead in turn to the incorporation of fresh insights and differing viewpoints.
- Logic.-If properly designed and programed, a computerized model will draw logically correct and mathematically error-free conclusions from an extremely complicated set of assumptions and data. This can lead to novel insights into unexpected or counterintuitive system behavior, reveal areas in which further research is needed, and expose assumptions that are inconsistent or contradictory.
- Flexibility and range.–By making small changes in the magnitude and relations of variables, it is possible to examine the implications of a wide range of alternate assumptions and to test the sensitivity of the outcome to changes in different parameters. The models can also be tailored to "fit" particular problems, regions, or issues. The model can therefore become a powerful planning tool, and properly updated runs can be used to monitor program progress.
- Instructiveness.–The flexibility of global models also makes them a valuable tool for analysts, planners, and policy makers alike, allowing them to examine a broad range of possible outcomes, responses, and policy options. This can allow them to reject physically impossible options, clarify the nature of various risks, and evaluate the adequacy of different options for minimizing those risks. Thus, even when the models cannot give precise quantitative answers, they allow the users to sharpen their analytic skills and improve their intuitive "feel" for the operation of the system.

[2] L. M. Ward, et al., "World Modeling: Some Critical Foundations," *Behavioral Science*, vol. 23, No. 3, May 1978, p. 138.

[3] See Donella H. Meadows, John Richardson, and Gerhart Bruckmann (eds.), *Groping in the Dark*: The First Decade of Global Modeling (New York: Wiley, forthcoming), pp. 20-21, 42-43, 203, 3 10-312; and Dennis L. Little, et al., Long-Range *Planning* (Washington, D.C.: U.S. Library of Congress Congressional Research Service, 1976), prepared for the Subcommittee on the Environment and the Atmosphere of the House Committee on Science and Technology, pp. 456-457.

# Limitations of Global Models

Despite these benefits, global models remain subject to a number of limitations that may constrain their accuracy, reliability, and usefulness for policy making:[4]

- Theoretical limitations.–The structures of different global models are based on underlying assumptions adapted from systems analysis and several other disciplines, including engineering, economics, and the natural sciences. There is no general agreement on the relative validity of their competing explanations of socioeconomic phenomena, nor is there any evidence that one approach produces results that are consistently more reliable than the others. In addition, theoretical understanding of a number of important processes (for example, the effect of socioeconomic conditions on fertility rates) is too weak to allow adequate modeling, although projections based on alternative assumptions can still be useful and instructive.
- Methodological limitations.–The essence of modeling is a simplification that improves understanding, but this means that a limited number of discrete factors and relations must be used to describe the dynamic complexity and ambiguity of the real world. Theoretical bias and data constraints often determine which variables and relations are included or omitted, but no model could include every factor without becoming as complicated as the real world.
- Data limitations.—Data vital to proper forecasting are often nonexistent, inaccessible, or unreliable. This is particularly true for environmental data and for most data on the LDCs. This situation has improved somewhat in recent years, but data limitations remain a serious constraint on reliability and on the sectoral and regional coverage that models can achieve. In some cases there are inadequate empirical data on which to base improvements in theoretical understanding.
- Practical limitations.–An effective global modeling effort requires considerable time, an interdisciplinary team of modelers and technicians, a large and continuously updated data base, access to computers of sufficient capacity, support services, and money. Skimping on any of these requirements greatly increases the risk of error and unreliability in the resulting forecasts.

[4] See Meadows, Richardson, and Bruckmann, op. cit., pp. 22, 43-44, 312-313; Little, et al., op. cit., pp. 458-459; Ward, et al., op. cit., and *The Global 2000 Report to the President*, vol. 2, ch. 14.

# Institutional Opportunities and Barriers

Since President Theodore Roosevelt created the National Conservation Commission in 1908, numerous presidential and congressional committees, commissions, task forces, and studies have recommended in one way or another that the U.S. Government should improve and/or institutionalize its long-range analysis, planning, and policy-making capability. The most recent study discussed in this report, The Global 2000 Report, reveals that, individually, the executive agencies possess an impressive, if uneven, capability for long-range analysis and forecasting within their separate areas of responsibility and interest; but it also reveals "that, collectively, the executive agencies of the government are currently incapable of presenting the President with a mutually consistent set of projections of world trends in population, resources, and the environment. "[5] Nevertheless, according to the report, "Important decisions—involving billion-dollar federal programs and even the national security—are partially based on these projections, " which "have generally been used by the government and others as though they had been calculated on a mutually consistent basis."[6]

[5] *The Global 2000 Report to the President*, vol. 2, p. 3
[6] Ibid., vol. 2, p. 45-I.

The interagency followup report, Global *Future: Time to Act,* carries these conclusions a step further:

> If there is one clear lesson from the exercise of putting the *Global* **2000** Report together, it is that the U.S. government currently lacks the capacity to anticipate and respond effectively to these global issues. . . . As of today, the government still does not adequately: 1) project and evaluate future trends; 2) take global population, resource, and environmental considerations into account in its programs and decisionmaking; and 3) work with other countries to solve these problems. T

The deficiencies in the Government's current foresight capability appear to be institutional rather than technical. In a recent analysis of the potential Government policy applications of computer models, A. D. Little found modeling to be potentially quite useful:

> Current state-of-the-art techniques in long-range forecasting of population, resources, and the environment present significant opportunities for the State Department to enhance its capabilities for analysis of the long-run future socioeconomic and political consequences of foreign national demographic, resource, and environmental conditions.[8]

After considering the various limitations of computerized modeling (see above), the A. D. Little report concludes that "Institutional conditions are often much more of a constraint to the effective use of forecasting models than methodological or data considerations."[9] These findings, although addressed to the Department of State, would appear to be equally relevant to the modeling activities of other agencies and of the Government as a whole.

The *Global* 2000 Report includes similar findings—the discrepancies and lack of integration among its forecasts arise:

> . . . essentially because of the institutional context in which the elements of the model were developed and are being used, This context emphasizes sectoral concerns at the expense of interactions among the sectors and leads to distorted and mutually inconsistent projections. 10

> This design is no institutional accident but is in conformity with the bureaucratic division of responsibility within the executive agencies [and within the committee structure of the U.S. Congress]. . . . Furthermore, in the absence of ongoing institutional incentives to address cross-sectional interactions, the present form of the government's global model is not likely to change significantly in the foreseeable future. [11]

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> Moreover, it would be naive not to recognize that projections and the procedures used to produce them have frequently been criticized by Congressional committees and others as subject to influences not purely analytical in origin. Each agency has its own responsibilities and interests, its own constituencies, and its own pet projects. Often, an agency finds it helpful to use advanced analytic techniques (and associated projections) as weapons in the adversary process of initiating, justifying, and defending its programs. As a result, there have been many occasions in which the elements (and associated projections) of the government's global model have been used in support of (or in opposition to) highly controversial programs, and the credibility of the projections has become a subject for debate. This has been especially true in recent times, as both the issues and the advanced analytic procedures used for examining the issues have become increasingly complex and, in a sense, incomprehensible to many nonexperts.[12]

Another analysis of the Government's current foresight capability points to these and similar institutional barriers. The following list of major obstacles presents 10 frequently cited reasons for the Government's failure to correct the perceived deficiencies in its existing foresight capability.[13]

1. There is little or no top-level support for foresight.
2. The "best talent" has never worked on broad, long-term issues.
3. Bureaucratic rigidity, compartmentalization, and specialization have frustrated attempts to promote cooperation among departments and to take a broad, long-term view.
4. Time pressures restrict vision to the short run.

[7]Nicholas Yost, staff director, *Global* Future: Time to Act, Report to *the* president on *Global* Resources, *Environment* and *Population* (Washington, D. C.: U.S. Council on Environmental Quality and Department of State, January 1981), p. 206.
[8]Arthur D. Little, Inc., op. cit., pp. ix-x.
[9]Ibid., p. xii.
[10]*The Global 2000* Report *to* the *President,* vol. 2, p. 454.
[11]Ibid., vol. 2, p. 461 and footnote.
[12]Ibid., vol. 2, pp. 478-480.
[13]John M. Richardson, Jr., "Towards Effective Foresight in the United States Government" (prepared for the U.S. Department of State, June 1979), pp. 13-18.

5. By the time models or forecasts are developed, policy-level officials have either moved on or lost interest.
6. Policy-level officials lack the knowledge and experience to properly use models.
7. The products of modelers' efforts are incomprehensible or irrelevant [to practical policy issues], or both.
8. There is poor communication among those who contract for models and" forecasts, those who develop them, and those who are supposed to use them.
9. Congress doesn't care about the long-term future.
10. The public doesn't care about the long-term future.