MODELS IN THE POLICY PROCESS: PAST, PRESENT, AND FUTURE

Warren E. Walker

September 1981

P-6654

MODELS IN THE POLICY PROCESS: PAST, PRESENT, AND FUTURE*

Warren E. Walker

The Rand Corporation

September 1981

---

*This paper was prepared for presentation at the Tenth IFIP Conference On System Modeling and Optimization, which was held in New York City, August 31-September 4, 1981.

In 1976, Greenberger, Crenson, and Crissey, in their book Models in the Policy Process [9, p. 26] wrote:

> Both model designers and sponsors share a general impression that the actual uses of modeling in government have fallen short of expectations. The gap between expectation and achievement is widest in the policy applications of modeling.

I am afraid that, if they were writing their book today--5 years later--they would come to the same conclusion. However, even though the conclusion might be the same, the intervening years have brought some important changes in the types of models being developed and how they are being used. These trends, coupled with major technological developments, portend significant changes in the use of models in the policy process. As a result, I believe that the gap between expectation and achievement will become considerably narrowed.

In this talk, I will describe the evolution of policy modeling. For expository purposes, I will divide the evolution into three periods:

- o the early years--the period from the late 1960's through the early 1970's
- o the recent past--the period since the early 1970's
- o the future

Forgive me if I include some simplifications and broad generalizations in order to make my points stark and clear. I have no doubt that each of you will have counterexamples for some of my statements. However, I hope you will agree that, overall, I have captured the essence of the field's past and future.

When I say policy models, I mean models that can be used to evaluate the consequences of alternative decisions that might be made by a policymaker, who is typically a public official. These models are usually designed, built, and used by policy analysts as part of a project to find solutions to problems confronting the policymaker.

EARLY YEARS

Policy modeling is not a new endeavor. It can be traced directly back to the operational analyses performed for the military during World War II. By the end of the war, a total of about 700 scientists had participated in studies that had come to be called operations research [20, p. 140]. After the war, operations research techniques were applied to a wide variety of systems. At first, most of the settings for these applications were in the private sector. Typical applications were in inventory control, production planning, and facilities location. The immediate clients for most of these early studies were lower-level managers who had operational responsibilities.

Gradually, as the methodological tools were improved and computers grew more powerful, models were developed to support higher managerial levels. By the early 1970's, analysts in the private sector had begun to build strategic planning models designed to support the decisionmaking responsiblities of top corporate management.

The use of quantitative analysis in the non-military sector of government lagged behind its use in industry by about ten years. Analysts began to apply mathematical models to the problems of state and local governments in the late 1960's. As in industry, most of the early efforts in the public sector focused on attempts to increase efficiency and effectiveness in situations where it was fairly clear what these terms meant and how they could be measured--such as in dispatching fire companies, designing police patrol areas, and scheduling hospital admissions (although there were some well publicized attempts to build comprehensive urban planning models, none of which was particularly successful*).

Even with the limited scope and objectives of these early policy studies, very few of them led to the implementation of new policies in the client agencies--the key measure of the success of a policy study. (I maintain that, even if the models used are elegant and the analysis impeccable, a policy study cannot be considered successful if it has no influence on policy decisions.) It is generally acknowledged that the process by which most of the analysis was carried out during this period

*See [16].

was responsible in large part for this notable lack of success. The relationship most commonly found among the analyst, the model, and the policymaker is illustrated in a simplified and exaggerated way in Fig. 1.

The model was central to the process. Often large and complex, the model required considerable amounts of data and was expensive to run. In many cases it was an optimization model or a comprehensive simulation model. The inner workings of the model were seldom understood by anyone but its builders. The analyst might spend a small amount of time with the policymaker at the beginning of the project defining the problem and identifying data sources, but after this modest interaction they would have little or no contact until the end of the project. After the analysis was completed, the analyst would present the results to the decisionmaker in the form of a briefing and/or a final report. More often than not the report remained on the shelf, and the results of the study were never used.

This process, viewed from the perspective of the roles and interactions of the analyst and policymaker in the various stages of the project, is depicted in Fig. 2. Here we see that the analyst and policymaker interact only at the very beginning and very end of the project. The analyst, with little or no input from the policymaker, builds the model, runs the model, and analyzes the results. He then presents his findings to the policymaker. By this time, the original problem may have changed considerably, the alternative solutions examined might no longer be viable, or the policymaker may have entirely forgotten about the project. Heiss [10] summed up this situation when he wrote (in 1974):

> The urban researcher has limited impact since, as related to the urban decisionmaking process, he comes late, leaves early, and does not get involved in implementation.

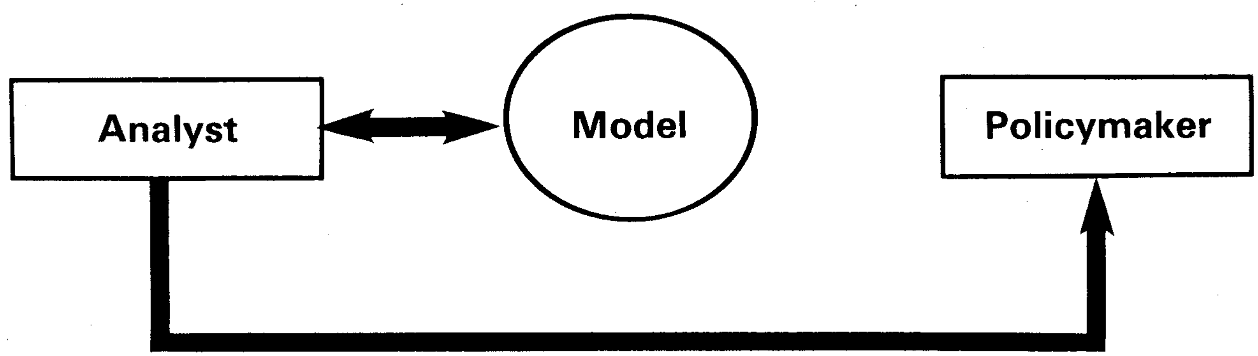

Fig. 1--Relationships among policymaker, analyst, and model: early years

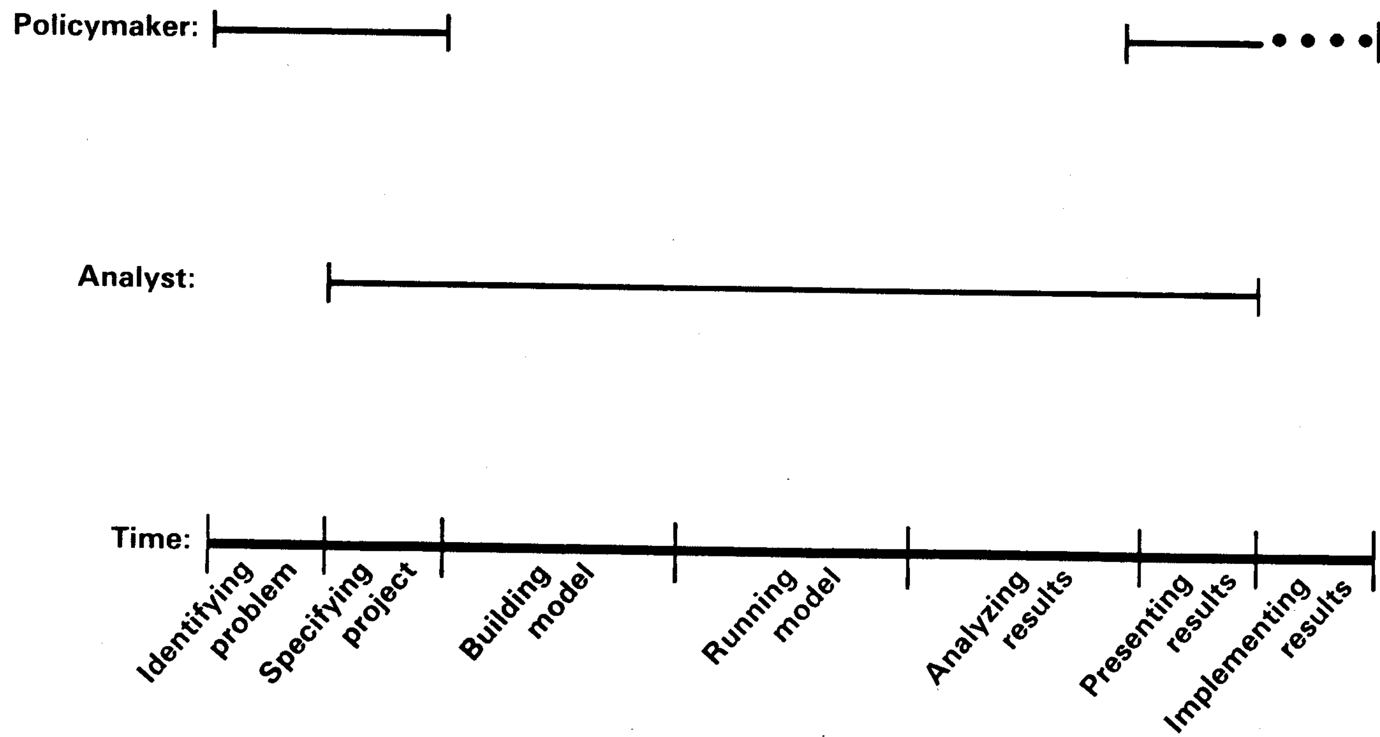

Fig. 2--Roles of policymaker and analyst: early years

RECENT PAST

The last few years have been a period of reassessment and revision. Analysts began to realize that models are only one element in a policy analysis study, and that most of the other elements play a more important role in determining the study's success. In particular, there has been a growing appreciation that, in order to make the analysis relevant, useful, and implementable, the analyst must interact much more closely with the policymaker and must obtain a much better understanding of the way he makes his decisions. As a result, much closer working relationships have developed between analysts and policymakers. As Roberts wrote [25]:

> The client is the boss ... [He must] be persuaded that you have properly taken into account his issues, his questions, his level of concerns. Otherwise he will not believe the model you have built, he will not accept it, and he will not use it.

In part because the focus has shifted from the model toward implementation of results, we have not recently witnessed any major methodological developments to match some of the breakthroughs in policy modeling that occurred in the earlier period. Instead, there has been a broadening of scope along several dimensions:

- in application areas
- in the level of policymaker who is the client for the analysis
- in the range of performance measures considered
- in the academic disciplines represented

In addition, the approach being used to model large systems is to build many interrelated and interacting smaller models instead of a single large model.

We discuss each of these developments in turn.

Application Areas

Policy models had their earliest successes when used to analyze the operating problems of government agencies. In recent years, practically no area of endeavor has escaped the eye of the modeler. For example, policy modeling has been successfully applied in such diverse areas as blood-banking [3], managing the spruce budworm in North American forests [1], locating rural social service centers in India [23], and protecting a Dutch estuary from floods [8].

Level of Policymaker

Policy studies using sophisticated modeling tools are being performed for policymakers at increasingly higher levels of government. This trend involves both a shift in the type of client for policy research (from lower-level managers and agency heads to top-level government officials) and in the types of problems being addressed (from the operational and tactical problems of an agency to strategic planning for an entire jurisdiction).

The primary models currently being used by top-level government officials are planning and budgeting models (see, for example, [21] and [5]). These models are used in a number of ways. For example:

- to help analyze the fiscal impacts of local government development policies
- to evaluate alternative economic, educational, social, and environmental policies before they are implemented
- to perform revenue and expenditure forecasting
- for goal setting and problem definition

The development and use of these planning and budgeting models parallels the development and use (about ten years earlier) of corporate planning models in the private sector.

Comprehensive policy analysis models for high-level government policymaking have also recently been constructed to analyze other areas, such as energy (see [6]), water management (see [8]), and the environment (see [11, p. 236]).

Performance Measures

Typically, early policy studies focused on one or two quantifiable criteria (such as cost, travel time to fires, tons of refuse collected, etc.) that were related to the stated objective of the study. However, there has been increasing acknowledgment by analysts that (1) there are usually multiple, and often conflicting, objectives in public-sector planning problems, (2) many policy impacts are not quantifiable, and (3) some of the policymaker's objectives are unstated and only dimly understood even by him.

These factors pose serious problems for the analyst who is trying to help a policymaker choose a course of action. Because of this, much attention in recent years has focused on how to handle them. One approach that has been developed for assessing the many projected impacts from a policy is called "decision analysis" (see [14]). In decision analysis, all of the impacts are quantified, and a weighted combination taken to produce a single measure of value, which can be used to rank the alternative policies. The weights are based on the value system or preference structure of the policymaker.

An alternative approach, which maintains the disaggregated information on individual impacts and handles qualitative as well as quantitative impacts, is to present the impacts in the form of a matrix called a scorecard. Figure 3 is a sample scorecard that presents selected results from a study that compared three alternative ways to protect a Dutch estuary from flooding [7]. The entries in each column represent the consequences associated with a particular alternative--in this case (1) permanent closure with a dam, (2) temporary closure with a storm surge barrier (SSB), and (3) leaving the estuary open but increasing the height of the surrounding dikes. The entries in a row show how a particular consequence varies from alternative to alternative. Each impact is expressed in terms of the natural units commonly used to characterize it (e.g., hectares, kilometers, number of beach visits per year). Qualitative impacts can also be shown (e.g., none, minor, or major for the impact on the attractiveness of the area), which enables the consideration of issues such as the equity of a policy or its impact on the quality of life. A color or shading scheme such as that shown here is normally used to indicate the relative rankings

	Alternatives		
	Closed case	SSB case	Open case
SECURITY			
Land flooded (ha) in 1/4000 storm (90% prob.)	0	0	400
Technical uncertainty	None	Scour	Dikes
Expected land flooded during transition pd. (ha)	430	200	530
RECREATION			
Added shoreline (km)	17	11	6
Added sea beach visits (1000/yr)	338	0	0
Decrease in attractiveness of area	None	Minor	Major
Major tourist site created?	No	Yes	No
Decrease in salt-water fish quantity (%)	75	0	25
NATIONAL ECONOMY (PEAK YEAR)			
Jobs	5800	9000	5700
Imports (DFL million)	110	200	130
Production (DFL million)	580	940	560

Rankings: Best Intermediate Worst

Fig. 3--Sample scorecard from policy analysis of the Oosterschelde (Polano) project

of the policies for each impact, but the process of making comparisons, tradeoffs, and selections among the policies is left to the decisionmaker's judgment and intuition. Removing the reliance on weights allows the analyst to present results that are relatively value-free. In addition, it makes it possible for different interest groups to agree on a single alternative (perhaps for different reasons), while they might be unable to agree on weights to assign to the various performance measures.

In addition to these efforts to determine how to combine, contrast, and/or present information on stated objectives to the policymaker, analysts have begun to address the more difficult issue of how to include a policymaker's hidden or unstated objectives (e.g. political and organization considerations) in the analysis. One potentially fruitful line of inquiry is to use models to generate a number of very different policies each of which performs about as well with respect to the stated objectives.* The policymaker can then choose among them based on factors other than those calculated by the models. Of course, the scorecard approach also lets the policymaker factor in the unstated objectives for each of the alternatives examined in the analysis.

Academic Disciplines

Broadening the scope of policy modeling in the areas of application, level of policymaking, and impacts considered has brought a concomitant increase in the number of disciplines represented on a policy study team. In the early period, although lip-service was given to interdisciplinary teams, most policy studies that used mathematical models were staffed almost exclusively with technical specialists--operations researchers, statisticians, and computer scientists.

In recent years, the staffing of many policy studies has been broadened to include a wide range of disciplines. Most staff members are experts in the various aspects of the system being studied. For example, an interdisciplinary project team at the International Institute for Applied Systems Analysis (IIASA) built a set of models to be used in

---

*See, for example, [2] and [26].

planning integrated regional development [17]. The agriculture module alone drew upon agronomists for information about crops, geographers for data about soil and climate, engineers for agricultural technologies, and economists for cost and resource allocation questions. Also included on the project team were hydrologists, demographers, and urban planners.

The increased focus on implementation of the results of a policy study have also led to the inclusion of psychologists, sociologists, and political scientists on the team. Their job is to understand the policy-maker, the organizational environment, and the political environment within which the policy must be accepted, implemented, and operated.

Many Small Models

The IIASA models mentioned above are a good example of the trend in modeling toward analyzing a large complex system by building an interlinked system of small models (or modules) rather than building a single, comprehensive, complicated, and expensive large model. In the modular approach (which some call the "Tinker-Toy" approach [11, p. 216]) each module simulates in sufficient detail the behavior of one aspect of the system. The module can be used separately to study the impacts of a proposed policy on a specific portion of the system, or interactively with other modules to study the behavior of the entire system. The output from one module can be used directly as input to another module, or tabulated, analyzed, and combined with outputs from other modules to form an input data set for a subsequent model.

In the IIASA model, each of five important aspects of a region's development was represented as a separate module: industry, agriculture, water, population, and migration (see Fig. 4). Certain data and values are shared or flow among them: prices, wages, water demand and cost, and labor availability. A central integration model allocates capital and labor among the sectors; and the linked models work out the consequences of alternative allocations.

A similar modeling approach was recently used in a policy analysis of the water-management system in the Netherlands [8] of the study was dubbed PAWN. In PAWN, the Dutch water-management system was divided into 12 sectors, each of which represented a major suppier or user of water

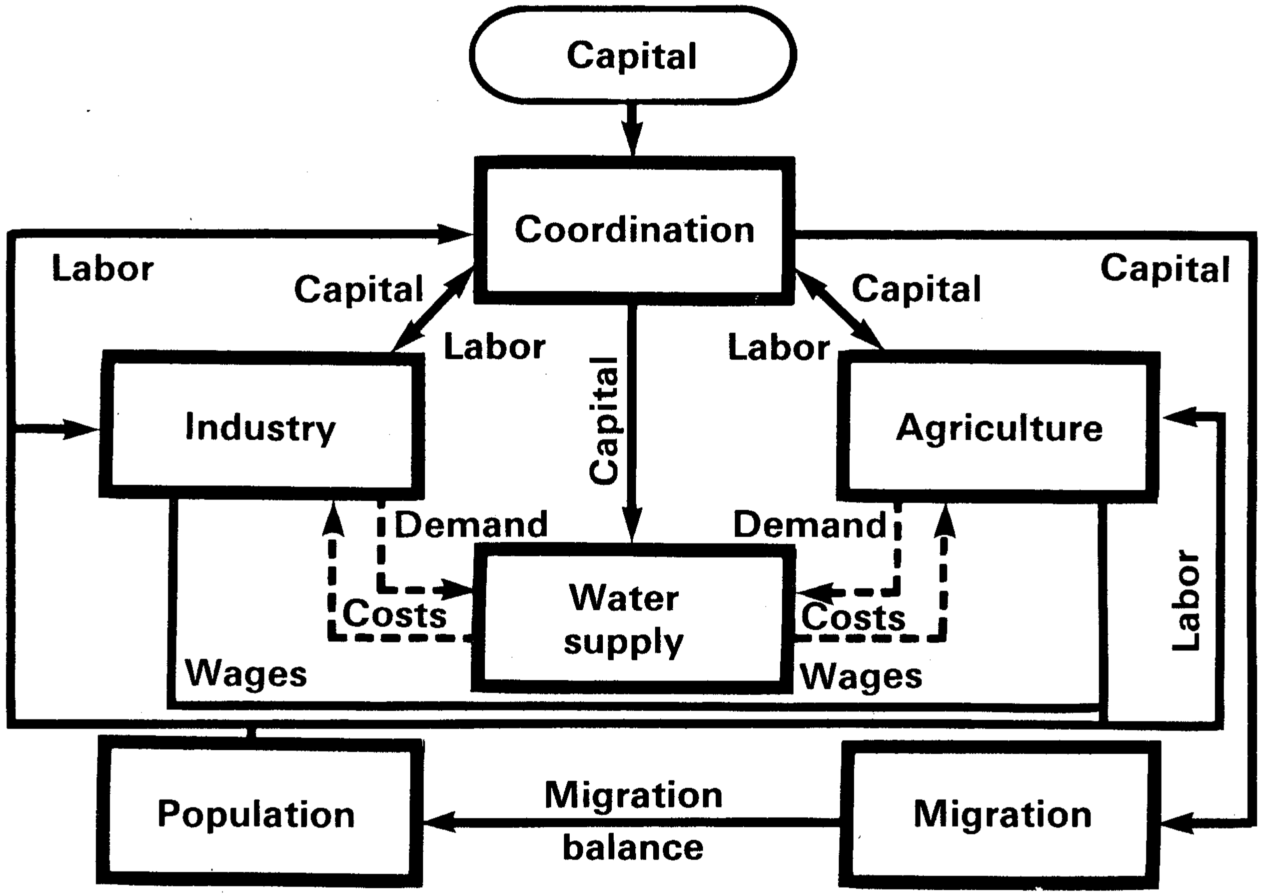

Fig. 4--IIASA system of models for regional development

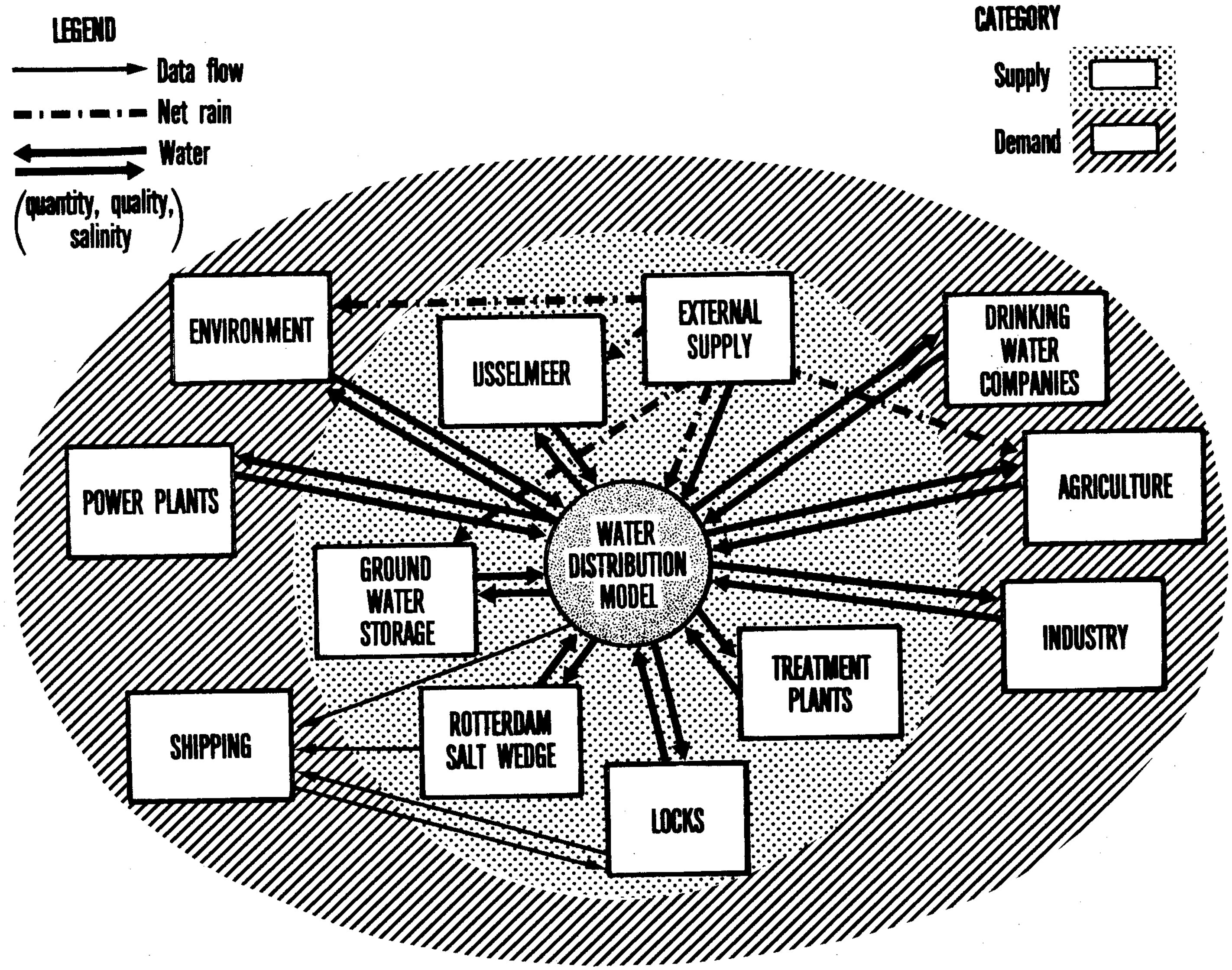

Fig. 5--PAWN system diagram

(see Fig. 5). Each of the sectors was modeled separately. Most of the models were then run separately, with outputs from one sometimes used as inputs to another. In some, cases, however, a subset of the models was run interactively, with one module calling another as a subroutine, and information being passed back and forth among the modules. Figure 6 illustrates the relationship among the Distribution Model (the central integration model, which simulates the flow of water throughout the country), the external supply sector (which supplies input to all the models), and a number of models representing the agriculture sector.

The modular approach to modeling is attractive for a variety of reasons. In addition to mitigating the problems inherent in building a single large model, it provides flexibility and convenience for the analysts, and facilitates communication with the policymaker. As summarized by Kunreuther et al. [15, pp. 21-22] the modular approach also makes it "relatively easy to adapt to a wide variety of circumstances, availability of data, and types of analyses without having to incur large amounts of time, skill, and confusion in reprogramming".

Highlights of Recent Past

Figures 7 and 8 highlight three of the most important recent trends in policy modeling. Perhaps the most important development, in terms of improving the chances for successful implementation, is the trend toward making a policy analysis study a joint effort of the analyst and the policymaker. Many recent studies have included the policymaker and members of his staff as full partners on the project team. The policymaker, therefore, has become involved in all phases of the project's work except for the actual running of the model.

Second, as Fig. 7 makes clear, studies of large complex systems have increasingly used several small models instead of a single, monolithic model.

Finally, as suggested by Fig. 8, analysts have increasingly recognized that the study does not end with the preparation of the final report. They have become increasingly concerned with the implementation phase. Their experiences in the early years made it clear that good analytical results do not necessarily lead to successful implementation (see, for

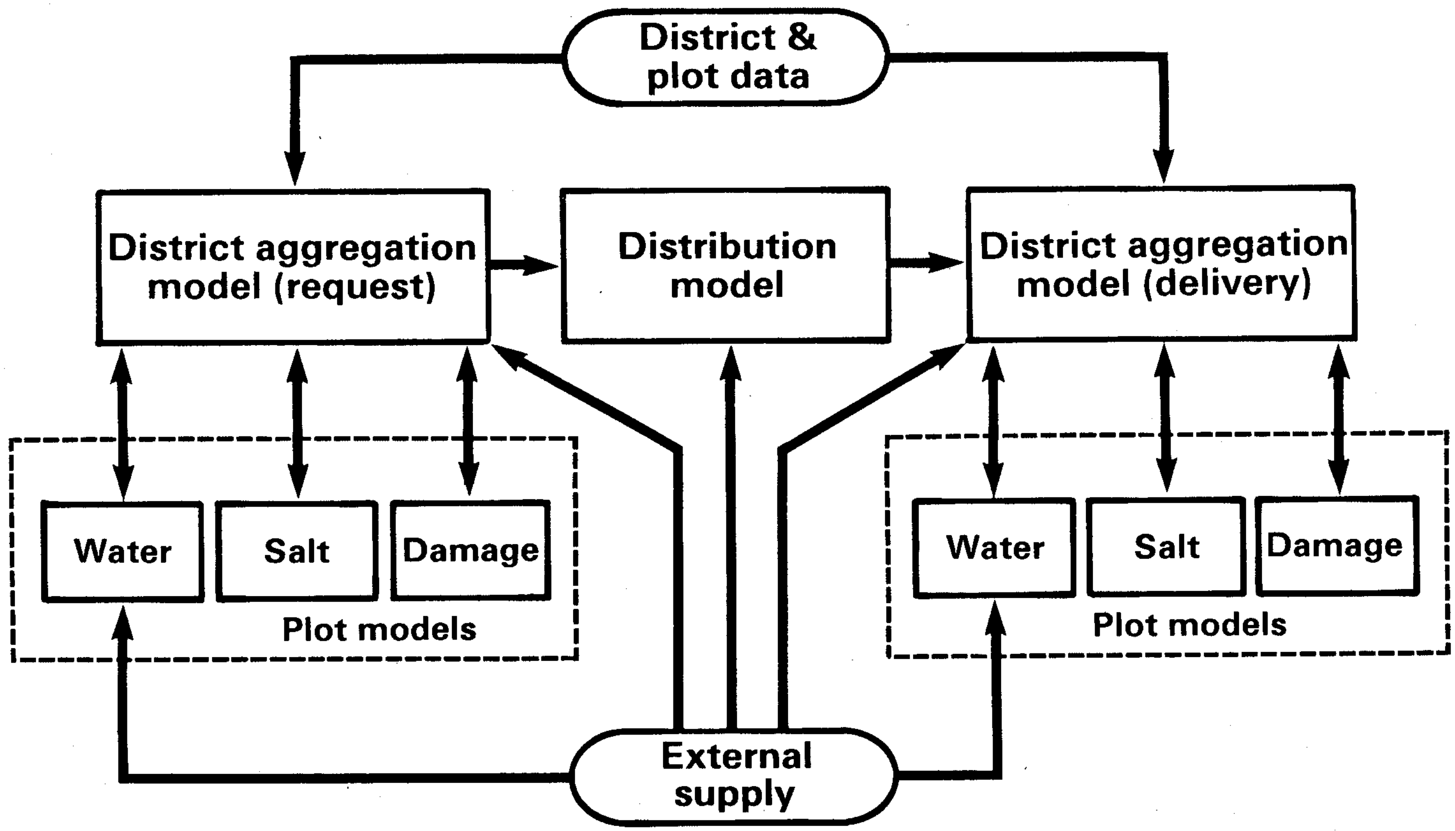

Fig. 6--Interactions among PAWN agriculture models

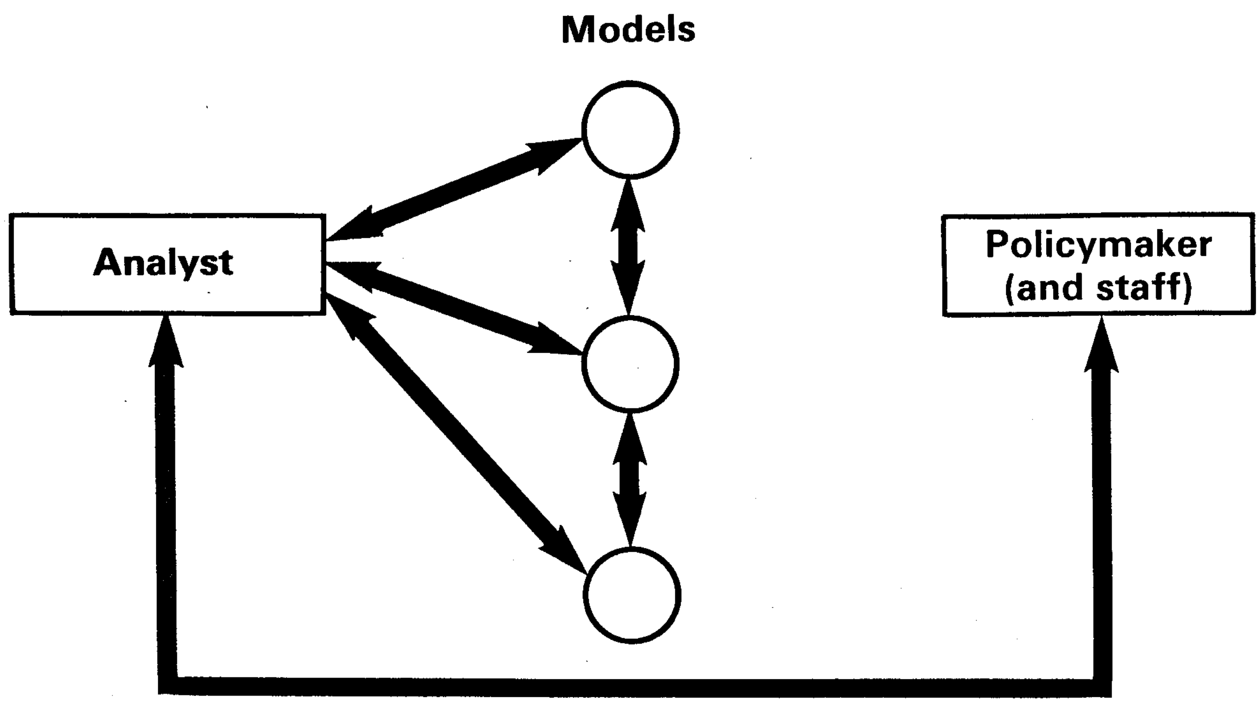

Fig. 7--Roles of policymaker and analyst: recent past

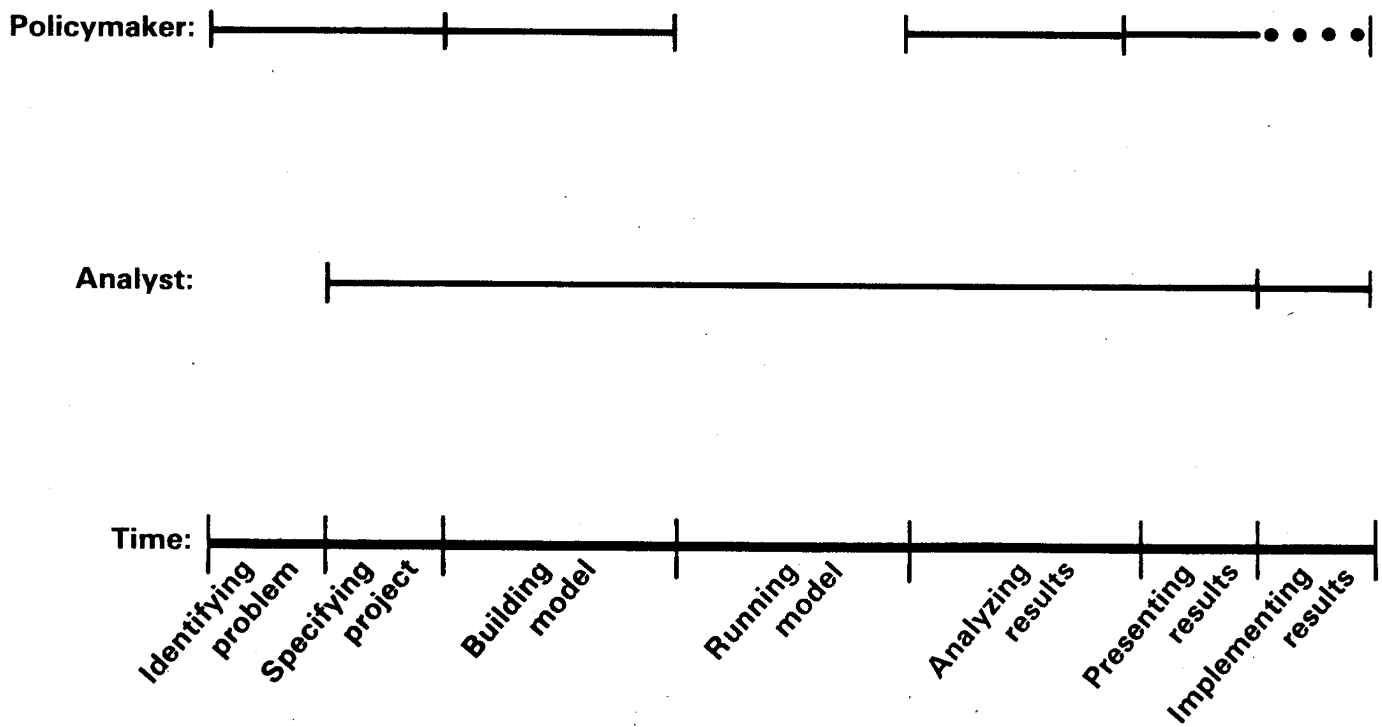

Fig. 8--Relationships among policymaker, analyst, and models: recent past

example, [28]). Thus, attention is now being paid to implementation during all stages of the study. Implementation costs and political and organizational problems are factored into the analysis; the study often includes the development of an implementation plan; and people knowledgeable in organizational behavior and the process of planned change are sometimes included on the project team.

THE FUTURE

The development of commercial time-sharing services in the late 1960's began a movement that is still accelerating--toward personalized computer systems, direct access to and interaction with models and data, and decentralization of computer resources. The availability of microcomputers, interactive terminals, and data communications networks has been growing exponentially. I believe that these developments have profound implications for the use of models in the policy process.

In 1977, there were about 200,000 microcomputers in use in the United States. A jump to three million operating units by 1984 is forecast [22]. In the not too distant future policymakers and members of their staffs will have computer terminals in their offices, much as they now have calculators. These terminals will give them direct and immediate access to policy models, and provide the potential for significant changes in the nature of policy analysis and the roles and interactions of the various participants in a policy analysis study.

The broad outlines of what may be in store can be seen in recent developments in the private sector, where increasing attention is being paid to on-line interactive systems that assist managers at all levels of a corporation in making their decisions. Such systems are broadly called "decision support systems" or DSSs [12].

Basically, a DSS embeds decision models in a management information system (MIS), and provides the decisionmaker with on-line access to both the information in the MIS and the outputs from the various models. The major elements of a DSS in a public sector setting are illustrated in Fig. 9.

At the heart of a DSS is the policymaker (not the policy model). The DSS's primary purpose is to support a policymaker in making decisions--to act as an extension of his own decisionmaking process, or, as others have phrased it, as "an executive mind-support system" [13].

Through use of a simple, forgiving, English-like command language, the policymaker interacts with both an integrated data base and an interlinked system of policy models. The command language acts as a buffer between the policymaker and the computer, and allows a "conversation" based on the policymaker's concepts, vocabulary, and definition of the decision problem.

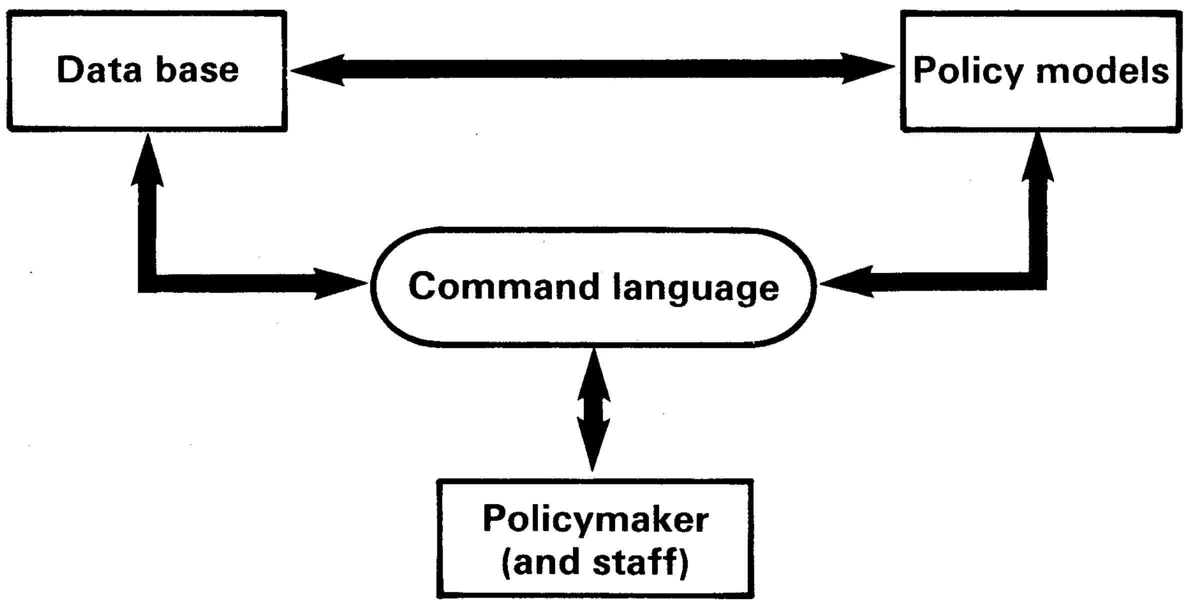

Fig. 9--Major elements of a decision support system

The data base retains all the relevant information about the policy area in an organized, systematic manner, and is continually updated. Policy models often fall into disuse because the input data gradually become out of date, and it is costly and inconvenient to collect the required new data on an ad-hoc basis. In the case of a DSS, the updating of input data is automatic and institutionalized.

The set of interlinked policy models (or modules) in a DSS is not unlike the sets of models we said were currently being developed for policy analysis studies. The individual modules are likely to be even smaller than the modules in current studies, and more easily combined to produce models that can analyze new situations or answer new questions in a dynamic environment. The models will draw the majority of their inputs from the data base and place much of their output back onto the data base. This output can then be used by other models as a source of input data.

In order to make the models attractive to policymakers and guard against their falling into disuse, they will tend to be self-documenting, easily updated,* and so easy to use that they will become a natural part of the policymaker's decision process. They will also be problem-oriented, and relevant to the real problems confronting the policymaker. The idea is <u>not</u> to automate the decision process or capture the essence of the decision process in one or more models. Instead, each module gives the policymaker information about those parts of the system that are structured and can be modeled. The policymaker then combines these outputs with personal knowledge, understanding, and judgments about those aspects of the situation that are not taken into account by the models, to reach a decision about the best course of action. While the process may require running some or all modules a number of times under various sets of assumptions, they are run under the control of the policymaker or his staff, to supply information he has requested and not information an outside analyst (or the management information department) thinks he should see.

---

*Updating procedures will be incorporated in the routine maintenance of the system so that changes are made to the models to match changes in the environment. Some changes would be made automatically--e.g. changes in the input data and new parameter values that can be calculated from information in the (constantly updated) data base.

The new technology that makes decision support systems possible also makes it possible to display information for the policymaker in ways that capture his attention and facilitate his understanding. Even now, the output of models can be displayed at terminals in the form of colored maps, pie-charts, histograms, etc. Graphic displays can even show the simulated behavior of the system over time.

In the future, "situation rooms" for policymakers might be developed, which would utilize large displays driven by the computer. House and McLeod [11, p. 96], in discussing this idea, said that the room should be designed to make the presentation of simulation results more intelligible and dramatic to policymakers, community groups, and concerned citizens:

> To this end, there would be calibrated dials labeled with the names of several of the more important exogenous variables and parameters that would be under the control of the experimenter. Furthermore the computer would be programmed to run in "rep-op," a mode in which a complete simulation is run and automatically repeated and displayed at a rate fast enough to change in apparently real time with the movement of the dials. Thus, serious researchers and the curious public alike could immediately see the probable long-term impact of proposed policy changes.

There are many documented examples of decision support systems that have already been developed and successfully used. Among the private sector examples are a corporate planning system for Xerox of Canada Limited [27], a planning and reporting system for Liberty National Bank [4], and a financial planning system for a large scientific research organization [18].

There are also a surprising number of public-sector decision support systems already in operation. For example, computer-aided dispatching systems for fire departments, police departments, and emergency medical services are decision support systems. The New York City Fire Department's Management Information and Control System (MICS) includes sophisticated algorithms for helping the dispatcher make rapid decisions concerning (1) how many fire companies to send to an incoming alarm, and which specific companies to send (see [24, Chap. 11]), and (2) how best to provide coverage to an area of the city when all of its fire companies are busy fighting fires (see [24, Chap. 12]).

The future role of models in the policy process that I have just sketched out is an extrapolation of earlier trends. As shown in Fig. 10, decision support systems continue the trend toward expanding the policymaker's role in a policy analysis study and making the study more responsive to his needs. Because the policymaker will be interacting directly with the models, he will have a better understanding of the meaning of the numbers produced by the models, a better feeling for the differences among the policies, and more confidence in the results. All of these factors should increase the chances for successful implementation.

Figure 11 indicates that the future policymaker will become a full partner in a policy study. He will be involved in every step of the process: from problem identification through implementation of results. Maintenance of a close working relationship between the analyst and the policymaker throughout the study will also do much to increase the chances that the study will be a success.

The fact that the policymaker and his staff will be playing a more active role in building policy models, running them, and analyzing the results, does not mean that there will be a declining need for policy analysts in the future. It only means that there will be a greater need for analysts to work within public agencies. In fact, since I foresee more widespread use of policy modeling, I expect that there will actually be a greater total number of policy analysts in the future. Many of them will continue to be employed by private research corporations and management consulting firms. Someone has to build the models, and I believe that most of them will continue to be built by outside parties, albeit with the active participation of representatives of the government agency.

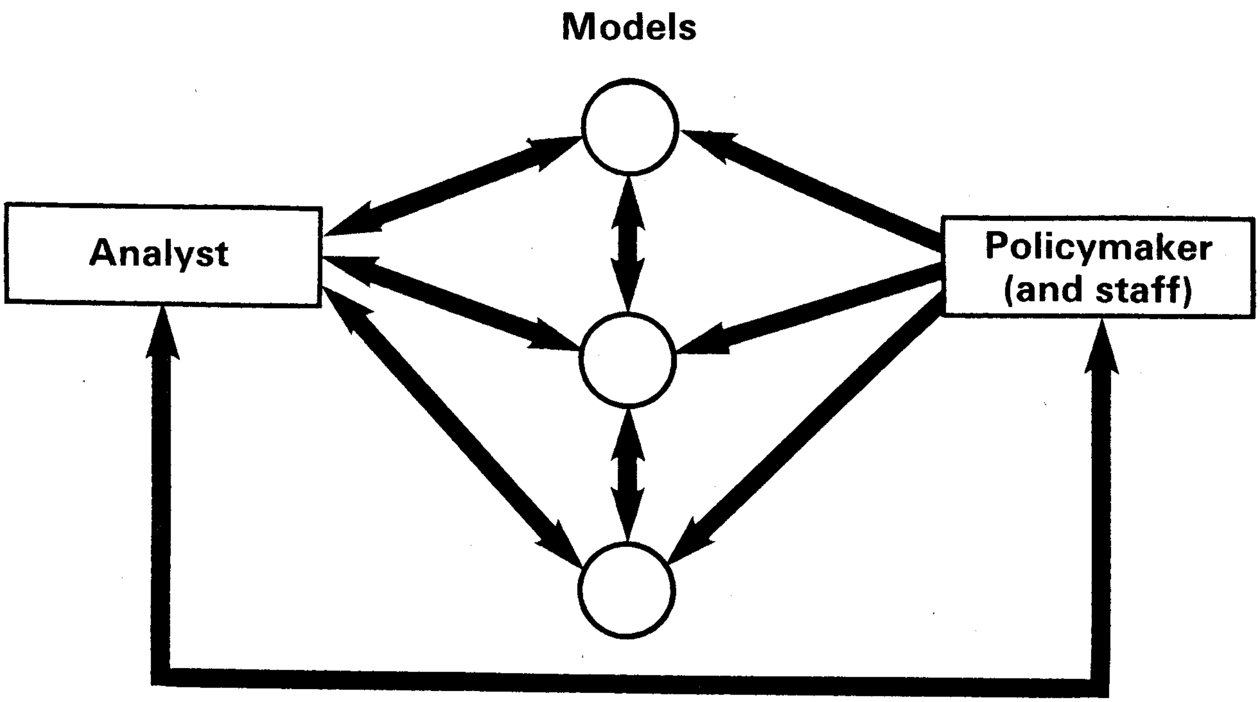

Fig. 10--Relationships among policymaker, analyst, and models: future

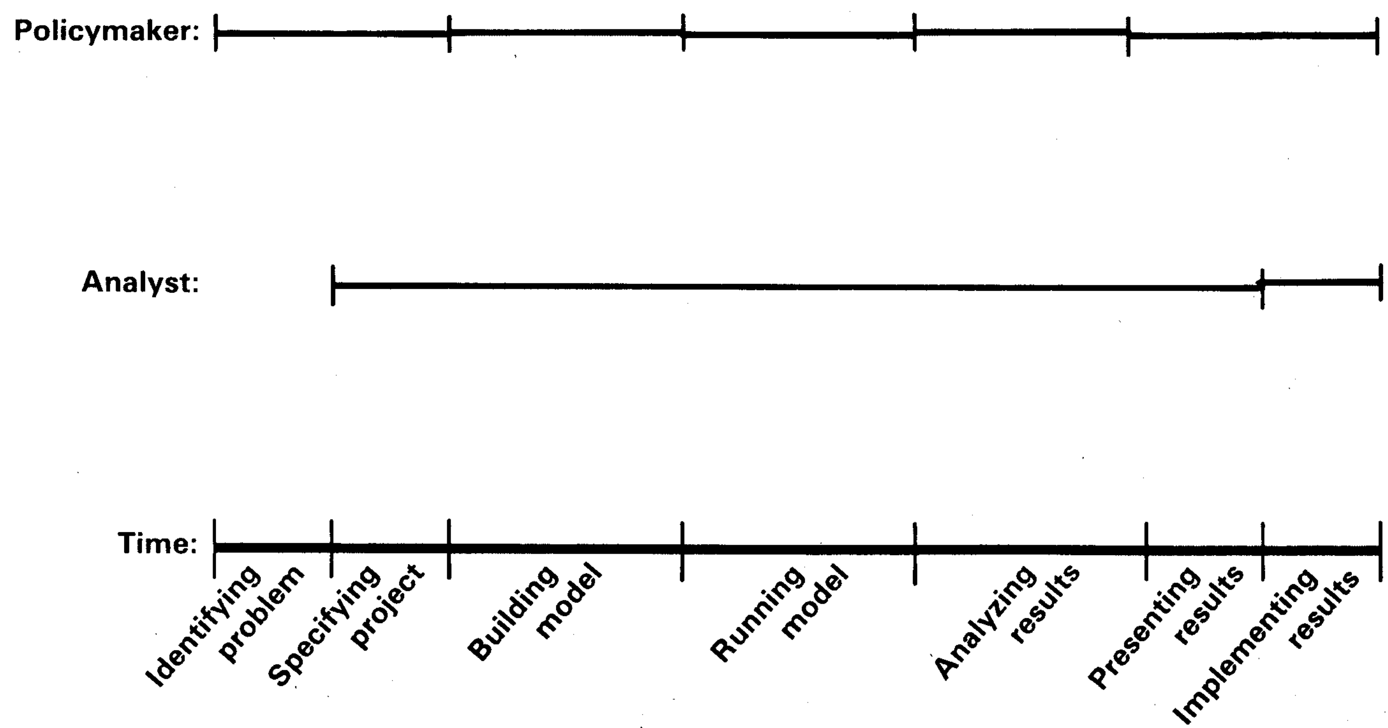

Fig. 11--Roles of policymaker and analyst: future

CONCLUSIONS

What does this excursion into the past, present, and future of policy modeling imply for the policy analyst and model builder? Based on evidence from the early years and even the recent past one might conclude that the use of models in the process of public sector decisionmaking has been tried for twenty years and has been found wanting. In other words, one might conclude that the public sector has had a brief fling with using computer models, and that their use is unlikely to grow much in the future.

However, I believe that the confluence of several independent developments has set the stage for a dramatic increase in the use of models in the policy process.

- First, there are the technological developments. In the past few years science fiction has become science fact. Microcomputers are being mass produced that have the capabilities of computers that used to fill a room, but at a fraction of the cost. Through telecommunications, these computers can be connected to others located almost anywhere. Interactive terminals give the user direct and immediate access to the computer. Data base management systems, query languages, and graphical displays provide information in a form that can be used directly by a decisionmaker.
- Second, decision support systems have gained acceptance as management tools in the private sector. While public agencies generally lag the private sector in the use of such tools, they eventually proceed along similar paths.
- Last, but perhaps most important, public agencies are beginning to experience unprecedented fiscal pressures. These pressures are likely to motivate the search for new, creative solutions to public sector management and service delivery problems.

Even though each of these developments has been evolutionary--the result of gradual changes in technology, managerial procedures, and fiscal conditions--their confluence portends a revolutionary change in the use of models in the public sector. In contrast to the negative tone of my opening remarks, my scenario for the future suggests that we may be on the threshold of a new era in the use of models for governmental planning and policy analysis.

REFERENCES

1. Baskerville, G., W. Clark, C. Holling, D. Jones, and C. Miller, Ecological Policy Design: A Case Study of Forests, Insects, and Managers, John Wiley & Sons, London (1980).

2. Brill, E.D., Jr., S. Chang, and L.D. Hopkins, "Modeling to Generate Alternatives: The HSJ Approach and an Illustration Using a Problem in Land Use Planning," Management Science, forthcoming.

3. Brodheim, E., and G.P. Prastacos, "The Long Island Blood Distribution System as a Prototype for Regional Blood Management," Interfaces, Vol. 9, No. 5, pp. 3-20 (November 1979).

4. Bruce, J.W., "Management Reporting System: A New Marriage Between Management and Financial Data Through Management Science," Interfaces, Vol. 6, No. 1, Part 2, pp. 54-63 (November 1975).

5. Dutton, W.H. and M.S. Hollis, Fiscal Impact Budgeting Systems, Public Policy Research Organization, University of California, Irvine (November 1979).

6. Federal Energy Administration, Project Independence Report, Washington, D.C. (1974).

7. Goeller, B.F., A.F. Abrahamse, J.H. Bigelow, J.G. Bolten, D.M. de Ferranti, J.C. De Haven, T.F. Kirkwood, and R.L. Petruschell, Protecting an Estuary From Floods: A Policy Analysis of the Oosterschelde, Report No. R-2121/1-NETH, The Rand Corporation, Santa Monica, California (December 1977).

8. Goeller, B.F., et al., Policy Analysis of Water Management For The Netherlands: Vol. I, Summary Report, Report No. R-2500/1-NETH, The Rand Corporation, Santa Monica, California (forthcoming).

9. Greenberger, M., M.A. Crenson, and B.L. Crissey, Models in the Policy Process, Russell Sage Foundation, New York (1976).

10. Heiss, F.W., Urban Research and Urban Policymaking: An Observatory Perspective, Bureau of Governmental Research and Service, University of Colorado, Boulder (1974).

11. House, P.W., and J. McLeod, Large-Scale Models for Policy Evaluation, John Wiley & Sons, New York (1977).

12. Keen, P.G.W. and M.S.S. Morton, Decision Support Systems: An Organizational Perspective, Addison-Wesley Publishing Co., Reading, Massachusetts (1978).

13. Keen, P.G.W. and G.R. Wagner, "DSS: An Executive Mind-Support System," Datamation, Vol. 25, No. 12, pp. 117-122 (November 1979).

14. Keeney, R.L. and H. Raiffa, Decisions With Multiple Objectives: Preference and Value Tradeoffs, John Wiley & Sons, New Nork (1976).

15. Kunreuther, H., J. Lepore, L. Miller, J. Vinso, J. Wilson, B. Borkan, B. Duffy, and N. Katz, An Interactive Modeling System For Disaster Policy Analysis, Program on Technology, Environment and Man, Monograph #26, Institute of Behavioral Science, University of Colorado, Boulder (1978).

16. Lee, D.B., Jr., "Requiem For Large-Scale Models," Journal of the American Institute of Planners, Vol. 39, pp. 163-178 (1973).

17. Levien, R.E., "Applied Systems Analysis: From Problem Through Research to Use," IIASA Reports, Vol. 3, No. 1, pp. 19-37 (January-March 1981).

18. Meador, C.L., and D.N. Ness, "Decision Support Systems: An Application to Corporate Planning," Sloan Management Review, Vol. 15, No. 2, pp. 51-68 (Winter 1974).

19. Mohan, J.J., "Starfire, F.D.N.Y.: Communications Computer Network," With New York Firemen, First Issue 1980, pp. 12-13 and 23.

20. Miser, H.J., "Operations Research and Systems Analysis," Science, Vol. 209, pp. 139-146 (July 4, 1980).

21. Naylor, T.H., H.E. Glass, J. Wall, and D.N. Milstein, SIMPLAN: A Computer Based Planning System for Government, Duke University Press, Durham, North Carolina (1977).

22. Palmer, S.D., "The Microcomputer Explosion," ICP Interface: Administrative and Accounting, Vol. 6, No. 1, p. 12 (Spring 1981).

23. Patel, N.R., "Locating Rural Social Service Centers in India," Management Science, Vol. 25, No. 1, pp. 22-30 (January 1979).

24. Rand Fire Project (W.E. Walker, J.M. Chaiken, and E.J. Ignall, eds.), Fire Department Deployment Analysis, Elsevier North Holland, Inc., New York (1979).

25. Roberts, E.B., in Simulation in the Service of Society, pp. 6-7 (January 1975).

26. Schilling, D.A., A. McGarity, and C. ReVelle, "Hidden Attributes and the Display of Information in Multiobjective Analysis," Management Science, forthcoming,

27. Seaberg, R.A. and C. Seaberg, "Computer Based Decision Systems in Xerox Corporate Planning," Management Science, Vol. 20, No. 4, Part II, pp. 575-584 (December 1973).

28. Walker, W.E., Changing Fire Company Locations: Five Implementation Case Studies, Stock No. 023-000-00456-9, U.S. Government Printing Office, Washington, D.C. (January 1978).

RAND/P-6654 MODELS IN THE POLICY PROCESS: PAST, PRESENT, AND FUTURE Warren E. Walker