

Reprinted from  
New Trends  
in Mathematical Modelling

Published by Ossolineum  
Wrocław 1978

---



AN ASSESSMENT OF DOCUMENTATIONS STANDARDS FOR TEN  
COMPUTER MODELS OF POLITICAL PROBLEMS \*

Nazli CHOUCRI

Massachusetts Institute of Technology

In recent years, computer models have been increasingly employed to examine political problems, and interest in their usefulness for decision-making has accordingly grown. Nonetheless the absence of agreed upon standards of documentation makes it difficult to evaluate them in a systematic fashion or to determine the ease with which they can be used. The purpose of this paper is to review the documentation available for 10 major computer models in political science — a first step in evaluating their usefulness and efficiency.

A fully documented computer model should, at a minimum, meet ten generic requirements<sup>1</sup>:

- 1) Provide a precise statement of purpose;
- 2) Present a verbal description of the system;
- 3) Describe the historical behaviour of the system and the data base;
- 4) Illustrate the central question dynamically in terms of reference modes;
- 5) Identify the system boundary and endogenous, exogenous and excluded variables;
- 6) Provide a causal diagram indicating the major feedback loops (and/or causal relations);
- 7) Present a computer flow chart diagram;
- 8) Provide the equations, specifying initial conditions, coefficients, functional form, and explanation of options available;
- 9) Present basic runs and sensitivity tests;

---

\* I am grateful to Dennis Meadows, Dartmouth College, for suggestions regarding the structure of this paper, and to Michael Levitt, the Brookings Institution, for general comments and for describing his attempts to adapt and use four computer models of political behaviour.

<sup>1</sup> These criteria are adapted from suggestions by Dennis Meadows, Lectures, Copenhagen July 1973 and from U.S. General Accounting Office, "Auditing a Computer Model" (mimeograph version, 1974).

#### 10) Make recommendations on policy.

In order to develop a computer model the author must, at some point, address himself to each of these issues. But in many cases the information is not publicly available and the output is presented with inadequate documentation regarding model structure, equations, options, data base, or reference mode. This situation is partly the result of the recency with which political analysis have turned to computer models for assistance in decision-making; and partly because of the absence of agreed upon documentation standards for computer models in other fields.

The ten models reviewed in this paper cover a wide range of political problems, have different purposes, and are of varying use to a decision-maker. They include models of international conflict, internal political development, external expansion, conflict resolution, international alliances, and cognitive processing in crisis situation. Table 1 lists each model, with a descriptive title, purpose, and authors and their present institutional affiliation<sup>2</sup>.

The procedure employed in this review is: first, to briefly describe each of these models, noting the extent to which they meet the 10 generic requirements; second, to compare these models in terms of a simple scoring system, reporting the results in tabular form; and third, to make some summary assessments regarding the current state of computer modelling in political science, drawing upon the comparisons and attendant scores.

### 1. UNITED NATIONS PEACE-MAKING

The purpose of the UN Peace-Making Simulation is to evaluate the performance of the UN system to date and speculate about its future behaviour. The model is composed of four ingredients: 1) an "operational UN Charter" which defines expectations regarding the possibilities and limitations of UN involvement in international disputes, 2) a formal statement regarding how these expectations are turned into decision-making, 3) a set of probabilistic equations for explaining and predicting UN successes and failures, and 4) a learning or feedback mechanism for revising the operational procedures in (1) above. The simulation is a process model with learning and forgetting feedback, and is, in turn, based on four assumption: quasi-resolution of conflict, avoiding uncertainty, probabilistic search, and organizational learning. The procedure is to work backward through the model from specific conflict outcomes to identifying the rules and precedents used in deciding the outcomes.

<sup>2</sup> In the absence of specific information, both title and statement of purpose are formulated by this reviewer on the basis of available documentation. Rarely do the authors themselves provide both title and statement of purpose.

Table 1. Ten Computer Models of Political Problems

Descriptive Title	Purpose	Author(s)	Present Affiliation
1. United Nations Peace-making Simulation	Analyze UN peace-keeping efforts by examining the diplomatic process in terms of precedent searches and evolving international norms for responses to crises. Employ causal modelling and artificial intelligence to identify precedents and paths to conflict resolution.	H. R. Alker C. Cristensen B. Greenberg	M.I.T. Pittsburgh Harvard
2. Formal Model of Modernization and Mass Politics	Explore in light of recent theory some of the social, economic and political problems in developing areas that hinder institution building and governmental performance and succession, and examine the policies that might lead to political stability or instability.	R. Brunner G. Brewer	Michigan RAND
3. International Alliance Formation and Dissolution Simulation	Identify the international events that lead to the formation of alliances, and the events and processes which lead to disintegration.	M. Leavitt	Brookings
4. Simulation of Policies in the Vietnam War	Test the alternative political and economic policies of the US government during the Vietnam war and examine the consequences of alternative military strategies on US casualties.	J. Milstein	Federal Energy Administration
5. Decision-Making in the Inter-Nation Simulation	Compare the decision-making processes modelled in an existing man-machine simulation of international relations with simulated decision-making	S. Bremer	Michigan

Descriptive Title	Purpose	Author(s)	Present Affiliation
6. Crisis Computer Model	To understand better the process of deterrence by determining the extent to which the behaviour of political decision-makers can be explained by psychological concepts to model the cognitive system of decision-makers.	I. Pool A. Kessler	M.I.T. M.I.T.
7. Cognitive Processes and Foreign Policy	To better understand and explain the cognitive processes in regard to foreign policy decision-making and to develop a cognitive map of individual decision-makers to be employed for predicting their responses to problem situations.	M. Shapiro M. Bonham	Hawaii American
8. Simulation Model of International Violence	Identify the major macro-international processes that result in international violence and determine the national policies that might reduce propensities for violence.	N. Choucri R. C. North	M.I.T. Stanford
9. Resource Scarcity and Foreign Policy	Explore the impact of domestic resource scarcities on foreign policy.	N. Choucri M. Laird D. Meadows	M.I.T. Dartmouth
10. National Growth and International Conflict	To better understand the domestic roots of international violence and the factors that lead nations to foreign expansion; to test the effects of alternative economic and military policies on international behaviour.	M. Bousfield N. Choucri	M.I.T.

The purpose of the model is not specified clearly, but the verbal description is adequate. There is a diagram that serves both as a causal diagram and a computer flow chart, and the authors provide a listing of the model and the major equations. Sensitivity tests are made to see how the model reproduces alternative conflict outcomes from the rules modelled to generate them. But the policy implications are not specified clearly, and the authors do not make any direct recommendations, although they do reach some conclusions regarding the behaviour of the UN system and the types of conflicts it deals with most effectively.

## 2. MODERNIZATION AND MASS POLITICS

The formal model of modernization and mass politics is designed to study the conditions under which a government would win or lose support in situations where there are competing requirements for resource allocations in their development programs. Modernization refers to economic, political and institutional changes. Mass politics refers to the political behaviour of aggregates not individuals. The model focuses on four specific aggregates: a) rural population, b) urban population, c) government, and d) political opposition. It is composed of three sectors or subsystems: demographic, economic and political.

The statement of purpose is not unambiguous and the key question is not specified dynamically, although one can identify a whole range of political issues that could be examined with the model. The verbal description of the system is fair and the authors do replicate the past behaviour of two developing countries (Turkey and the Philippines) and use these as reference runs. There is a clear definition of the model in terms of system boundary, endogenous, exogenous and excluded variables. A flow chart is provided but not a causal diagram. A listing of the program is included, specifying initial conditions, coefficients and data base, and the authors do make some sensitivity runs. However, the model is too simple to be a guide for policy-making, although it is an excellent pedagogical device and is being used in courses on modelling political behaviour. This model was originally written in FORTRAN and rewritten in PL/1 for pedagogical use at M.I.T.

## 3. INTERNATIONAL ALLIANCES

The International Alliance Formation and Dissolution Simulation was designed to enable a researcher to understand how international events lead to the formation and dissolution of alliances. It is essentially an explanatory model of international alliance based on a logical structure of sequences of events. The logic used is grounded in prevailing theories of international alignments. It has not been designed for any policy uses,

nor does the output suggest any ready policy recommendations. The statement of purpose is implicit. There is a good verbal description of the model, but an incomplete description of historical behaviour. The central question is not posed dynamically nor are reference modes specified. The data are adequate and a listing of the computer model is provided. System boundary, endogenous, exogenous and excluded variables are all clearly specified. There is computer flow chart but not a causal loop diagram. The model is structured on the basis of logical connections, and not on functional or statistical relationships. Basic runs are presented and some sensitivity tests are made. The model was never designed to address a specific problem, nor does it have specific policy implications. But it is very useful for testing hypotheses about development and breakdown of alliances among nations.

The model is written in FORTRAN IV and is available on two machines, IBM 360/65 and Digital Equipment PDP-10.

#### 4. VIETNAM SIMULATION

The Simulation of Policies in the Vietnam war has as its purpose to test and predict the impact of alternative economic and political decisions upon US casualties and the conduct and outcome of the war. It was designed for policy purposes and has clear policy implications. But the statement of purpose is not as clear as would be desirable, although the verbal description of the model is good. To some extent, the issues are posed dynamically. With respect to structure, there is a clear statement of system boundary, of endogenous, exogenous, and excluded variables, and a computer flow chart diagram. The program listing is available from the author. Considerable effort is made in terms of sensitivity tests. The author presents the results of both the basic reference runs and the alternative policy runs, and makes some policy recommendations. Although this model was designed specifically for analyzing the Vietnam war, it is a useful tool for exploring the consequences of alternative policies in a military confrontation.

The model is written in FORTRAN IV and had been run initially on IBM 7090 and revised for IBM 360/67.

#### 5. DECISION-MAKING SIMULATION

Decision-Making in the Inter-Nation Simulation is designed to compare how decisions are made in two settings: a) a man-machine simulation of international processes, the Inter-Nation Simulation (INS) at Northwestern University, and b) an all machine simulation of international decision-processes. The INS is the major large-scale man-computer modelling effort in the field of international relations, and the effort to cu



pare decision-processes is undertaken for theoretical purposes only and has no direct policy implications. The author attempted to simulate the rules of the human decision makers and in this respect, the statement of purpose is clear. But the verbal description of the model is not complete; there is some description of the historical behaviour of decision-making. The problem is not posed dynamically, and there are no reference modes against which the output of alternative runs is compared. The simulation is not time dependent, but is run on the basis of discrete "periods", thus making a dynamic definition of the purpose difficult.

The author does present the computer flow chart diagram, the equations, coefficients and data base. Sensitivity runs are made in terms of changing environmental conditions and observing their consequences for the behaviour of decision-maker and the decision rules adopted. Although the simulation does provide some insights into decision-making in international contexts, there are no explicit policy implications nor can any policy recommendations be made. This computer model was clearly not intended to assist in policy-making.

## 6. CRISIS COMMUNICATION

The Crisis Communication Computer Model was designed to better understand the role of psychological principles in decision-making and, by extension, to explore the process of deterrence and the reaction of one party to signals and communications from another. The model was structured to process incoming information through a series of psychological propositions and to anticipate the response in terms of adherence to these principles. The statement of purpose is thus general and not posed sharply. However the model is tested against historical communication data in crisis situations (most notably communication among the belligerents during the six weeks prior to the outbreak of World War I). There is an implicit statement of system boundary and endogenous, exogenous and excluded variables. There is a diagram that serves both as a causal diagram and a computer flow chart. The model is composed of logical connections and not of functional or statistical relations. A listing of the computer program is presented as well as the results of some basic runs.

The authors do not make policy recommendations, other than the general statement that an understanding of cognitive processes in decision-making is important as is an appreciation of the psychological principles followed. This model is no longer operative since the computer on which it was initially built for and run on has been replaced. But the structure has provided the inspiration for a subsequent model, noted below, designed specifically to understand the cognitive processes in foreign policy making.

From a scientific perspective, therefore, this model has had important uses.

This model was written for MIT/CTSS, the Institute's time sharing system which has been replaced by MULTICS.

#### 7. COGNITIVE PROCESSES AND FOREIGN POLICY

The Cognitive Processes and Foreign Policy Model has its origins in the Crisis Computer Model. It is composed of a set of bivariate causal relations representing the cognitive map (or individual beliefs) of decision-makers. The operational purpose is to run the model on data regarding the external events or international actions, and observe how these are processed through the simulated decision-maker's belief system to yield a set of decision outcomes.

A decision-maker's belief system is represented as a map of the relations between three types of concepts: a) affective concepts, referring to the policy objectives of the decision-makers, b) cognitive concepts, referring to beliefs about events which occur in the international system, and c) policy concepts, reflecting possible alternatives or options from which a decision-maker may select policy recommendations. (The linkages are either positive or negative, to indicate the nature of the relationship among concepts). Five processes are invoked when a decision-maker is confronted with a new international situation which may require a response from his government: First, placing the new event in the context of his own experiences; second, searching for precedents; third, searching for consequences in terms of anticipated outcomes if his government does not act; fourth, searching for policy alternatives in terms of the options available; and, finally, selecting policy options from a given set of alternatives.

The documentation is very poor. The statement of purpose, the verbal description of the model are only fair. The historical behaviour of the system is not well presented, although the data regarding the contents of different belief systems is well documented. The issue of reference modes is not really relevant since the questions they are concerned with are not posed dynamically. There is, however, a clear definition of system boundary, endogenous and excluded variables. There is also a causal diagram, but it is extraordinarily complex and extremely difficult to follow. It is composed of an intricate network of bivariate relations which represent strictly causal relations. But these are neither functional nor statistical relationships, but rather a series of logical causal connections. The authors do not provide a computer flow chart diagram, nor do they present a basic run or undertake sensitivity tests. As presently structured, the model does not have clear policy implications and the authors do not make policy recommendations. However, the model can, potentially, be a powerful tool for assisting in the making of foreign policy, with its structure modified appropriately.

## 8. INTERNATIONAL VIOLENCE

The Simulation Model of International Conflict is designed to provide a better understanding of the causes of war. It is an econometric model of the relationship among national expansion, intersections among spheres of influence, military competition, international alignments, and violence behaviour. It seeks to identify the national policies that could reduce the trends toward violent conflict, and to examine the implications of alternative policies.

The statement of purpose is not very precise, but there is a good verbal description of the model, its historical behaviour, and the data upon which its parameters are based. But, the central question is not stated dynamically nor are there reference modes against which the results of sensitivity test are compared. The basic run is designed to correspond with historical processes during a specific time period, and, is used, in effect, as the reference mode.

There is a clear statement of system boundary, in terms of endogenous, exogenous and excluded variables, and the causal diagram is provided along with the individual equations. The model is structured to meet all the criteria and restrictions of econometric models. The few sensitivity tests undertaken are designed specifically to test the consequences of alternative military budget policies, and some general policy recommendations are put forth. But the major effort has been in building the model and estimating its parameters from empirical data. The use of the model for policy purposes was basically an after thought: the initial purpose was to understand and replicate the cause of war with reference to a particular historical period.

The model is written for TROLL/1, the time sharing system for the estimation and simulation of econometric models developed by the National Bureau of Economic Research and run on IBM 360/67.

## 9. RESOURCE SCARCITY AND FOREIGN POLICY

The computer model designed to examine the impacts of resource scarcities of foreign policy was developed as a pilot study for a large-scale project to examine problems of long-term resource availability for the United States. The statement of purpose is general and not sufficiently precise. The model description is good, but there is an inadequate explanation of the choice of parameters or functional forms. There are some verbal sketches of the historical relationship between resource scarcity and foreign policy. The central questions are not presented dynamically nor are there a specific reference modes for the model. However, there is clear definition of system boundary, time horizon, and of endogenous, exogenous and excluded variables. The authors present causal

loop diagrams for each of the sectors of the model, and a combined diagram for the model as a whole, but they do not present the flow chart diagrams, thus making it difficult to others to understand precisely what has been done. A listing of the computer model is appended, excluding the key parameters and initial conditions, thus, again, making it difficult for others to use their model. Several sensitivity tests are undertaken, and a comparison of the results is presented. Given the absence of a clear statement of purpose, it is perhaps well that the authors do not make any policy recommendations. However, this pilot study, undertaken primarily to map out some international consequences of technological growth, and resource depletion has provided the background and modelling experience for subsequent studies with specific policy purposes.

#### 10. DETERMINANTS OF LATERAL PRESSURE

Lateral Pressure refers to the propensities for extending national behaviour outside territorial boundaries, and is a major cause of international violence. Historically lateral pressure resulted from national growth and the depletion of domestic resources: the more rapidly a society is growing, the greater its lateral pressure. Lateral pressure is generally high and growing during periods preceding the outbreak of war. Historically there is always a marked increase in lateral pressure before a major war. This has been observed before World War II, the Korean War and the Vietnam War. Involvement in war, in effect, absorbs a society's lateral pressure. The computer model of the Determinants of Lateral Pressure has as its purpose exploring the effects of alternative economic and military policies on the expansion of U.S. behaviour outside national boundaries.

Lateral pressure is modelled as a function of a society's economic growth and excess production and of the impact of population growth and resource scarcity. The model is composed of five sectors including: a) population, b) resource availability, c) economic growth, and d) military allocations. Each sector is designed to yield an individual multiplier upon lateral pressure, that fifth sector. The boundary of the system is well specified, in terms of endogenous, exogenous and excluded variables, and the parameters are derived from historical data. The central question is posed dynamically in terms of the alternative behaviour modes for US foreign policy over time. There is a computer flow diagram, but not a causal loop diagram. The model replicates known historical behaviour of the key variables very well over the period 1930—1970. A series of sensitivity tests are undertaken to test the implications of alternative military, economic, resource and demographic policies on the behaviour of the system during the next 30 years. But the authors do not yet draw policy recom-

mentations nor do they make full use of the model for purposes of policy analysis.

The model is written in DYNAMO II for MIT/TSO, the Institute's current time sharing system.

#### COMPARISON

Table 2 compares the 10 models according to their documentation standards and the extent to which they meet the generic requirements noted at the beginning. These comparisons are sketchy at best and must be viewed only as a rough assessment of performance. The scoring system is:

- 0 = requirement not met
- 1 = requirement poorly met
- 2 = requirement well met

The score range for each model is 0-20; similarly, the extent to which each generic requirement is met ranges from 0-20.

Table 2 indicates that, when viewed in terms of the 10 generic requirements cited at the onset, these models reflect a set of documentation priorities that are largely inconsistent with those we have considered as generic. The performance of these models in terms of the generic requirements appears as follows: Most models present a list of equations; there is a good verbal description of the model, its historical behaviour and system boundary; there are generally some basic runs and sensitivity tests however, reference modes are not always clearly specified; the purpose of the model is seldom stated clearly; there is either a causal loop diagram, or a computer flow chart, not both; rarely are the reference modes specified; still even more rarely are policy recommendations made.

Most of these models were not designed to assist in policy-making, nor were they regarded as having explicit uses for policy purposes. Policy recommendations are thus viewed as being outside the perview of the modeller's interests and/or capabilities. Only 4 of the 10 models reviewed were designed with an explicit policy purpose in mind (1. Formal Model of Modernization and Mass Politics; 2. Simulation of Policies in the Vietnam War; 3. Cognitive Processes and Foreign Policy and 4. Determinants of Lateral Pressure), and only two placed a great emphasis on sensitivity tests and examining the consequences of alternative policies (1. Simulation of Policies in the Vietnam War and 2. Determinants of Lateral Pressure). Clearly, political scientists are not yet making full use of their models for policy purposes, nor are they viewing the need to make policy recommendations as a primary objective of their modelling efforts.

By far, the most widespread concern among political scientists is for obtaining a better understanding of the system modelled and for testing

Table 2. A Summary Assessment

	Purpose	Verbal Description	Historical Behaviour	Reference Modes	System Boundary	Causal Diagram	Computer Flow Chart	Equations	Basic Runs and Sensitivity Test	Policy Recommendations	
Alker Christensen Greenberg	1	2	2	0	2	1	1	2	2	0	13
Brunner Brewer	1	1	2	1	2	1	1	2	2	1	14
Leavitt	1	2	1	0	2	1	1	2	2	0	12
Milstein	1	2	2	2	1	1	1	2	2	2	16
Bremer	1	1	1	0	1	1	1	2	1	0	9
Pool Kessler	1	1	2	0	0	1	1	2	1	0	9
Bonham	1	1	1	0	1	1	0	0	1	0	6
Choucri North	1	2	2	1	2	1	0	2	1	0	12
Choucri Laird Meadows	1	1	1	0	2	2	0	1	1	0	9
Bousfield Choucri	2	2	1	2	2	1	2	2	1	0	15
	11	15	15	6	15	12	8	17	14	3	

Range = 0 - 20

scientific propositions (or "theories"). Fitting computer models against empirical data is the most dominant procedure employed and empirical criteria are used to evaluate the model's performance — not its usefulness for policy purposes. Most often, these criteria are statistical, and the laws of probability are resorted to as the final arbiter of the model's performance.

## REFERENCES

(ordered accordingly to numbers of corresponding models)

- [1a] Alker H. R., Jr., and Greenberg W. J., *The UN Charter: Alternative Pasts and Alternative Futures*, [in:] E. H. Fedder, ed., *The United Nations: Problems and Prospects*, University of Missouri, St. Louis, Mo., November 1971, pp. 113 - 142.

- [1b] Christensen., *From Causal Modelling to Artificial Intelligence: The Evolution of a UN Peace-Making Simulation*, [in:] J. A. Laponce and Paul Smoker, *Experimentation and Simulation in Political Science* [eds.], University of Toronto Press, Toronto 1972, pp. 177–224.
- [2] Brunner R. D. and Brewer G. D., *Organized Complexity: Empirical Theories of Political Development*, The Free Press, New York 1971.
- [3] Leavitt Michael, *A Computer Simulation of International Alliance Behaviour* Ph. D. Dissertation, Northwestern University, 1971. The model is written in FORTRAN IV and is available on two machines, IBM 360/65 and Digital Equipment PDP–10;
- [4] Milstein J. S., *Dynamics of the Vietnam War: A Quantitative Analysis and Predictive Computer Simulation*, Ohio State University Press, Columbus, Ohio, 1974. The model is written in FORTRAN IV and had been run initially on IBM 7090 and revised for IBM 360/67;
- [5] Bremer S., *National and International Systems: A Computer Simulation*, Ph. D. Dissertation: Michigan State University; to be published by Princeton University Press, 1970.
- [6] de Sola Pool I. and Kessler A., *The Kaiser, The Tsar and the Computer Information Processing in a Crisis*, *The American Behavioral Scientist*, Vol. VIII. No. 9, May 1965, pp. 31–38.
- [7] Shapiro J. and Bonham G. M., *Cognitive Process and Foreign Policy Decision-Making*, *International Studies Quarterly*, Vol. 17, No. 2, June 1973, pp. 147–174.
- [8a] Choucri N., *Applications of Econometric Analysis to Forecasting in International Relations*, *Papers, Peace Science Society (International)*, Volume XXI, 1973, pp. 15–39.
- [8b] Choucri N. and North R. C., *Nations in Conflict: National Growth and International Violence* San Francisco: W. H. Freeman, 1975.
- [9] Choucri N., Laird M. and Meadows D., *Resource Scarcity and Foreign Policy: A Simulation Model of International Conflict* Cambridge, Mass.: M. I. T. Center for International Studies, 1972.
- [10] Choucri N. and Bousfield M., *The Determinants of Lateral Pressure; A Forecasting Model of the United States, 1930–2000* Cambridge, Mass.: M. I. T. Center for International Studies, 1975.

