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## 7. From Correlation Analysis to Computer Forecasting: Evolution of a Research Program

**Nazli Choucri**

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One of the most important challenges in the study of international relations today is the development of reliable means of forecasting international outcomes. Forecasting is a problem of reasoning, of reducing uncertainty, and of bounded and disciplined speculation. It involves bringing theory, data, and methodology to bear upon our understanding of a specific substantive issue and translating this understanding into scientific terms for systematic testing, validation and replication (Choucri, 1974a, p. 63). Exploring the unknown, identifying possibilities associated with different outcomes, and isolating likelihoods of occurrences constitute the essence of forecasting.

The purpose of our work is to identify the determinants of conflict among nations and isolate the policies that could reduce the probabilities of international violence. Specifically, we have been developing empirical models to assist in (a) understanding the relationship among the multiple and interactive causes, (b) exploring the implications of alternative policies, and (c) undertaking contingent forecasts of alternative futures. This paper presents a critical review of our work to date,

delineates its cumulative aspects, presents some specific findings, and describes our research program of forecasting in the field of international relations.

### THEORETICAL DEVELOPMENTS: EMERGING PERSPECTIVES ON INTERNATIONAL CONFLICT

International conflict has been accounted for in a variety of ways—in terms of territoriality, aggressive tendencies, the protection of trade routes, the "mad" leader, imperialist drive, and so forth—but few systematic efforts have been made to provide some order among the contributing causes of conflict. Our approach has been to decompose the problem of war and, through quantitative analysis, identify various determinants and isolate the weights attributable to each (Choucri and North, 1972, p. 80). The basic procedure employed is to isolate those aspects of international behavior that are most amenable to systematic inquiry, develop indicators of their underlying characteristics, and employ these as the initial basis for developing and

testing empirical models of international conflict. In any investigation of this kind, however, a certain parsimony is required which, if unchecked, can border on oversimplification. The problems encountered were extensive, and, at each stage, our solutions have reflected both the achievements and limitations of the field of international relations at that point.

In operational terms, our research procedure was to (1) begin with simple correlation analyses of military and economic variables; (2) isolate their relative weights in contributing to conflict and warfare; (3) develop models of these interrelationships; (4) test these models against empirical data from different historical situations and cases; (5) observe the results and abstract functional relationships; (6) reformulate the model, taking into account misspecifications, changes in the phenomena under investigation, and so forth; and (7) respecify the model for purposes of forecasting and policy analysis.

We began with an analysis of national profiles and found that international behavior appears to be related to national attributes and capabilities. It gradually became clear that the underlying determinants of conflict behavior may lie less in observable factors which are readily defined as political, than in aspects of national orientation and characteristics which have conventionally remained outside the bounds of politics: Much of what we call politics may be shaped and constrained by factors which often lie beyond the political scientist's disciplinary concerns.

On the basis of empirical analysis we have gradually developed the view that the dynamics of *population growth*, those of *resource* constraints, flows and utilization, and those related to *technological* developments and transfers together shape political behavior and determine the parameters of permissible outcomes (Choucri, 1972).

Careful and often painstaking analysis of different situations, different nations, different times and different places yielded important clues regarding the relation of these three aggregate variables to conflict behavior. Analyses of the origins of World War I, the interwar period, Germany and Japan, the Scandinavian countries over a century, and the Middle East today, among others, provided the basis for this population-resource-technology

perspective. The causal network appears to be as follows:

Population acquires political implications when the combination of growing population and developing technology places increasing demands upon resources, resulting in internally generated pressures. The greater the pressures, the higher is the likelihood that national activities will be extended outside of territorial boundaries. If two or more countries with high capability and high pressure tendencies extend their interests and their psycho-political border it is highly probable that the two opposing spheres of interest will intersect. The more intense the intersection, the greater the chance that competition will assume military dimensions. When this happens, competition may be transformed into an arms race or a cold war, and perhaps even into a conflict. At the more general level of abstraction, provocation can be considered the final stimulus for large-scale conflict or violence. But an event will be considered as provocation only in a situation that has already been dominated by expansion, competition, armament tensions, and increasing levels of conflict behavior.

We have found that: (1) the dynamics underlying the development of conflict situations are highly volatile; (2) they change over time; and (3) longer-range causes differ from shorter-range, more immediate considerations. Rarely is the outbreak of war a random phenomenon; it is the consequence of developments which originate in aggregate demographic, ecological, technological, and economic factors. *This is not determinism.* It is an explicit attempt to formalize the constraints on national behavior and on political outcomes. The purpose is to reduce our uncertainties concerning future trends and events within some range of probability. The philosophical tone is one of probabilism.

Such a perspective is necessarily interdisciplinary, drawing upon current work in demography, in the economics and politics of resource allocations, flows and distributions, and in problems and processes of technological development. It has expanded our theoretical interests into directions which were not foreseen during the early years of our research. We also became concerned with the ways by which long-term considerations provided

the parameters for short-term behavior and with the operational linkages between long-term dynamics and short-term imperatives. The connections are still loose, and neither our own empirical analyses nor those of other scholars have provided sufficient indication as to the nature of the operational linkages. This problem emerges as one of the greatest shortcomings of quantitative approaches to international relations, and one which we are profoundly aware of. So, too, the problem of "intersection" among time perspectives remains largely unresolved.

The major theoretical developments resulting from earlier empirical analyses was a movement from profile analysis to *process* analysis and an awareness that the determinants of international conflict must be viewed as a dynamic process, and not simply as a series of correlational factors. An important step in the direction of process analysis has been to depict the general behavioral dispositions of nations with different population-resource-technology profiles, and, on that basis to identify war-prone and peace-prone tendencies (Choucri with the collaboration of North, 1972).

Developing the theoretical bases for modelling the dynamic processes that generate these (and other) *alternative* international behaviors amounted to a major challenge. Estimating the coefficients of a process model was only one side of the coin, the other is understanding the intricacies by which the model output is generated. It is extremely difficult to specify (conceptually and theoretically) the consequences of several second and higher order non-linear feedback relations. This type of conceptual requirement is often posed by our attempts to understand the determinants of international behavior.

We attempted to further identify theoretically and empirically those factors that might be manipulable by national leaders for changing national behavior, and the associated costs of manipulation. Isolating the identifying manipulables and the policy instruments that might be employed to change the behavior of a system has now become a central concern of our work. Thus, providing the theoretical linkages between the underlying determinants of international violence, and the day-to-day concerns of the policy maker amounts to a challenge, one we have only begun to confront.

In sum, the theoretical basis of our investigations has been highly cumulative: We began by seeking to isolate the key variables that, on the basis of pilot investigations, appeared to be important in conflict situations and moved to: (a) developing profiles of attributes and behavior, (b) mapping different profiles unto different observable patterns of international behavior, (c) focusing on the interrelationship among population, resources, and technology as three critical macro-societal determinants of international behavior, (d) adopting this three-dimensional perspective of international behavior as the basis for developing process models of international conflict, (e) seeking to link empirically long-term causes to short-term decision, and finally (f) adopting a policy focus and seeking to identify the interventions and instruments that might be employed to modify the behavior of a system or to reorient a war-prone system to alternative directions.

The present emphasis is on policies, instruments, and manipulables. It is on developing the theoretical basis for thinking about, modeling, and simulating future behaviors. And it is on delineating the theoretical and methodological bases for forecasting in the field of international relations. Our current investigations focus on the ties that bind nations in their attempts to meet their individual needs. Our substantive concerns are now extended to determining the parameters of *interdependence* among nations, the mutual sensitivities and vulnerabilities, and shared utilities (Choucri with Ferraro, 1974). We now seek to identify empirically the ties that bind nations in their attempts to meet their individual demands and to forecast future patterns of links and ties that may lead to conflict or violence. Analyzing patterns of global interdependence thus represents the most recent stage in the development of an evolving theoretical framework in the analysis of international conflict.

#### METHODOLOGICAL DEVELOPMENTS: PROBLEMS OF A CUMULATIVE RESEARCH STRATEGY

The first attempts in analyzing quantitative data were primarily of a correlational nature in that indicators of conflict were correlated with indi-

cators of national attributes and characteristics, with the expectation that some preliminary inferences could be drawn from observable associations. Through trial and error more precise theoretical guidelines were developed and we acquired a more sophisticated perspective on international behavior and conflict that went beyond the statement in our initial request for support from the National Science Foundation.

From an interest in associations and correlations, we moved to dependence analysis (regression and path analysis) and gradually the questions we raised necessitated multi-equation causal modeling and eventually computer based simulation.<sup>1</sup> The errors we made at each stage can be described only as monumental, and in retrospect we remain impressed by the collective ignorance of such methodology in the field as a whole.

It is only in retrospect that we appreciate the time and effort spent on seemingly technical matters. Because there appeared no precedence in the field for such work, at each stage we remedied our own errors. Consultations with colleagues in other fields were invaluable. But the danger of acquiring some moderate sophistication in one methodology lies in attributing to it greater capabilities than is warranted by the algorithms involved. For this reason we began to look at *alternative* options available for the analysis of international processes. And we redefined our generic methodological problem as one of *identifying the best type of algorithms for analyzing different aspects of conflict behavior*.<sup>2</sup>

A combination of skepticism and eclecticism gradually governed our approaches to questions of methodology. We became concerned as much with ways of analyzing past data as with methods of drawing inferences concerning alternative futures. These developments led to an initial assessment of the philosophical underpinnings of the orthodox behavioral approach in the study of international relations. The assumptions underlying statistical analysis also became the subject of greater scrutiny than they had been during earlier years. And a

systematic search for alternative research paradigm resulted.

A concern with the costs and benefits of alternative methodologies for examining long-range system behavior led to an experimentation with system dynamics. System dynamics refers to a philosophical approach to complex systems as well as a set of algorithms for depicting nonlinear feedback relationships. Despite the current controversies concerning the uses of system dynamics as a methodology, we have found that its requirements pose serious challenges to our conceptualization of the processes leading to war. The first effect in this direction was revealing—though halting and tentative (Choucri, Laird, and Meadows, 1972). Since then we have attempted to combine the data requirements of statistical and econometric methodologies with the conceptual demands imposed upon the investigator by an approach, such as system dynamics, which requires as complete a specification of system behavior as possible.

In spite of the many uncertainties and the problems we encountered, we strongly feel that our methodological development has been highly cumulative. Alternative views concerning the nature of causality and its operational indicators and alternative methodological approaches have become part of the methodological repertoire in most international relations courses. This is an extremely worthwhile development. The view of international “realities” has been broadened and many pertinent questions regarding the assumptions of the orthodox behavioral position have been raised.

In earlier years we were concerned primarily with linearities in variables and with the intricacies of bivariate analysis. The current challenges include modelling endogenous system change, taking into account system breaks and nonlinearities, specifying decision algorithms and learning processes, and so forth. We now lend greater emphasis to negative findings, to patterns of residuals, and to statistical anomalies or artifacts than we have tended to do in the past. Our present assessment is that our investment in time and energy over the past several years has yielded a high return at the methods level, one that perhaps exceeds the return at the theory level since gaps remain between the theoretical framework and the methodology. How-

<sup>1</sup> For these stages in the development of our work, see North and Choucri (1968), Choucri and North (1969), and Choucri (1973).

<sup>2</sup> An initial illustration is provided in Choucri (1974a).

ever, major developments in the analysis of international conflict have resulted.

#### **THE DEVELOPMENT OF DATA SERIES: PROBLEMS OF COLLECTION AND DOCUMENTATION**

Undoubtedly the most painful aspect of our work involved the development of time series data on the attributes, capabilities, and behavior of 12 powers from 1870 to the present. These data were collected at annual intervals from a series of sources, a system that provided a check against any inherent bias in the reliance on single source. In this respect we believe that we have contributed substantially to the availability of longitudinal data for the analysis of international relations. Portions of these series are now available to the academic community; others are still being refined. We have been hesitant to allow either colleagues or students to employ these data extensively until we have some estimate of measurement error for each individual variable.<sup>3</sup> This task is now completed.

In view of our interests in the underlying determinants of international behavior we have begun to collect information on resource flows—both mineral and energy—so as to identify the major networks of interdependencies among nations along a dimension which appears crucial to national security and international behavior. The current controversies concerning energy issues have reinforced our belief that much international behavior can be clarified by a careful analysis of transactions along the resource dimension. This perspective amounts to a variant on contemporary analyses of trade and aid flows and provides some useful additions to existing data banks. (See Choucri with Ferraro, 1974.)

The preoccupation with data collection has been accompanied by a tendency to "allow the data to speak for themselves," a situation that could be potentially misleading if theory is grounded entirely in observable data. Measurement error can often result in erroneous inferences. Data must be placed in their proper perspective; they must be used to seek out alternative explanations of observable phenomena. The present focus is

<sup>3</sup>This work represents one of the many collaborative efforts with Robert C. North, Stanford University.

upon (a) articulation of the premises underlying the use of alternative data series, (b) the development of extensive documentation for each datum collected, and (c) the specification of the theoretical link among underlying concept, empirical variable, and operational measure.

Documentation is itself a threefold issue: first, it must specify attributes and assumptions underlying individual data series; second, it must delineate the expected linkages among data, operational indicators, and underlying theory; and third, it must document the uses of empirical data in alternative strategies of analyses of computer modeling. Developing adequate documentation for underlying theory, operational model equations, computer language, and empirical data is acquiring an increasingly important role in our approach to quantitative analyses of international behavior.

#### **SOME EMPIRICAL FINDINGS: ILLUSTRATING A CUMULATIVE RESEARCH STRATEGY**

By way of illustrating the developments in theory, methodology, and quantitative analysis, we present some empirical findings from recent investigations. This is a highly selective review with only the most brief references and explanations given. However, sufficient information data bases, methodology, and sources are provided; the interested reader may refer to the original study.

#### **National Growth and International Violence**

The following findings are drawn from a recent study on the determinants of international violence.

[1] There are complex causal links among indicators of national growth and indicators of external expansion and violent behavior.

[2] Population growth and technological developments contribute to military capability: the relation is positive, causal, and direct.

[3] The higher the budgetary allocation to the military, the greater appear to be the expansionist tendencies of nations and the more violent the intersections among their spheres of influence. Such intersections, in turn, contribute to increasing military expenditures.

[4] National growth, increasing military expenditures, and greater intersections among spheres of influence contribute to move violent international behavior.

[5] Military competition results more from domestic growth and expansion than from external factors. However, allocations to the military influence patterns of international alignments and, through feedback effects, military competition; thus, arms races are accentuated.

[6] Once competition sets in, action leads to reaction, and violent behavior results in more violence. A classical Richardson process describes the dynamics of interactions among nations which results from the expansion of national interests outside territorial boundaries.

[7] A conflict system is more sensitive to upward swings in military expenditures than to downward swings. Policies designed to decrease military expenditures have less impact on the direction of a conflict spiral, and are generally less effective, than are policies designed to increase military allocations. Such upward swings move the system toward greater competition, expansion, allocations to the military, and violence.

[8] A conflict system is characterized by strong inertial effects. Once the conflict spiral is set in motion, the underlying process determines overall system behavior, rendering almost all interventionist policies largely ineffective.

The theoretical base for these investigations, presented initially in verbal terms, is specified further in the form of a probabilistic model linking national attributes to international behavior. The empirical data are composed of annual observations for six countries over a 45-year period. The methodology employed is econometric analysis for estimating the coefficients of a system of simultaneous equations. The analysis was undertaken in TROLL/1, an interactive computer system developed by the National Bureau of Economic Research, which was designed to estimate, simulate, and forecast econometric models. Simulating the model has allowed for experimentation with alternative values of key coefficients in order to examine the implications of alternative policies upon the behavior of the system modelled (Choucri and North, 1975).

### Determinants of National Expansion

The following findings are drawn from a simulation and forecasting model of lateral pressure, a term employed to refer to national propensities for external expansion. The forecasts to the year 2000 are based on a good fit between simulated and empirical data for 1930-1970 and on a set of assumptions generally accepted by social scientists, namely, that an ideal U.S. economy is one that is characterized by being balanced, with no petroleum shortages, and with a military budget that is no more than half the total government budget.

[1] An increase in technology generates an increase in the society's excess productivity, thereby increasing lateral pressure or propensities for external expansion.

[2] A decrease in technology generates a partial depression and, by extension, causes less lateral pressure.

[3] Any marked decreases in petroleum reserves create economic shortages that generate a decrease in Gross National Product and, by extension, a decline in lateral pressure.

[4] An increase in military expenditures leads to a slowing down of the GNP, to depression, to overproduction, and to technological stagnation.

[5] Although an increase in military expenditures generates lateral pressure, the effects are mediated somewhat by the negative impacts upon GNP; the net expansionist propensities are thereby lower than would be the case were GNP to continue to increase.

[6] An increase in the fraction of the total government budget allocated to civilian use allows GNP to grow faster, thereby generating underproduction and less propensity for expansion. The greater the civilian budgetary allocations, the lower lateral pressure appears to be.

[7] A decrease in population growth leads to a lower increase in GNP, which, in turn, causes less lateral pressure than would be the case were population to continue to grow.

The theoretical bases of these investigations are specified in a system dynamics process model of the structure of lateral pressure. The data are composed of annual observations for the United States, 1930-1970. These observations enabled the estimation of coefficients for the model, on the

basis of which forecasts to the year 2000 were undertaken. The above results refer to the forecasts beyond 1970 (Choucri and Bousfield, 1975). The model was built in DYNAMO, a system dynamics language designed to model functional relationships in a feedback nonlinear system.

### International Implications of Population Dynamics

The following findings are based on a cross-national study of population dynamics and international conflict.

[1] The role that population variables play in a conflict situation varies extensively: in some cases population factors provide the parameters of a situation and define the context within which a conflict unfolds; in others, population provides a multiplier effect upon a conflict by exacerbating the preexisting form or model; in still other instances, population may act as a variable, when in itself might change in the course of a conflict, or alternatively, cause a change in the nature of the conflict.

[2] In 38 of 45 cases of conflict in developing areas (1945-1971) population factors have been sole determinants in four cases. They were of (a) central importance in 11 conflicts; (b) major irritants in 10 situations; (c) minor irritants in 7 cases; (d) of background significance in 6 cases; and (e) they had no appreciable influence on the development or conduct of the conflict in 7 of the 45 cases examined.

[3] Population appears most frequently as a *parameter* of a conflict situation, then as a *multiplier* effect, and last in order of frequency, as a *variable* in a warring situation.

[4] Population *size* is most frequently a parameter; population *change* emerges most often as a multiplier upon an already existing conflict; population *distribution* is also a multiplier; and population *composition* emerges most often as a parameter of a conflict situation.

[5] There is no evidence that population density per se leads to conflict and violence.

[6] But there is a statistically significant positive correlation between the rate of population change and its criticality in a conflict situation in developing areas. The higher rate of growth, the

more salient a factor population increase appears to be in the development of conflict and violence.

These findings are drawn from a study of population dynamics and international violence. Forty-five cases of conflict in developing areas were examined, drawing upon the files in CASCON (Computer Aided System for the Analysis of Local Conflict) and employing comparative case study analysis (Choucri, 1974b).

### Energy Politics and Global Interdependence

The following findings are drawn from an analysis of the links, policies, priorities, and constraints that bind nations in their attempt to meet their respective energy needs (Choucri with Ferraro, 1974).

[1] There have been dramatic changes in the structure of the world petroleum system over the past 20 years. These changes are reflected in patterns of production, consumption, imports, and exports.

[2] These changes include (a) a transformation from the West as the focal point of petroleum production and exports to focal points in other areas of the world, and (b) changes in the rank order of exporting countries, again with a receding importance of the West.

[3] These changes have led to an increased reliance of consumer countries upon imports, an increased trend toward diversification in the sources of imports, and to clear asymmetries with respect to mutual dependencies between imports and exports. In some cases the asymmetries favor the importer, in others they favor the exporter.

[4] There have been important structural changes in the world petroleum system, particularly in the roles of multinational corporations and that of the Organization of Petroleum Exporting Countries.

[5] Although oil-producing countries rely heavily on consumer countries for trade in capital-intensive commodities, these commodities can be obtained from the consumers interchangeably, thereby providing the producers with a certain economic and political maneuverability.

[6] The balance of payments problem, from the perspective of the consumer countries is, in

fact, a problem of absorptive capabilities and surplus revenue from the perspective of the producers. This dual issue illustrates most dramatically the economic interdependencies in the world today.

[7] There are emerging networks of interdependence among the oil-producing countries, based on differentials in attributes and capabilities and upon complementarity in such differentials. This interdependence is having, and will continue to have, a strong influence upon global interactions and upon the future shape of the world petroleum system.

[8] Continued increases in petroleum prices will increase the consumer countries' investments in alternative sources of energy. A global energy system based on alternatives to petroleum will be characterized by different networks of links, ties, policies, priorities, and different configurations of inequalities in the international system.

[9] The major requisites for alternative global energy systems are defined by (a) alternative patterns of control over energy resources; (b) the distribution of energy resources; (c) the attendant price structure; and (d) the development of regulatory mechanisms for moderating global energy transactions.

[10] The nature of these system requisites would be very different depending on the type of international regime developed to regulate transactions and flows of energy. At least four different regime alternatives are identifiable: a free market regime, a joint regime, a multilateral regime, and an international regime. Each will invariably be characterized by different patterns of control, distribution, price, and regulation.

These findings are based on a cross-national analysis of the energy profiles, production, consumptions, and imports of the major consumers and producers of petroleum over the past 25 years and on a systematic assessment made regarding the implications of a world energy system based on an alternative to petroleum. The analysis included coal, nuclear energy (fission and fusion), solar energy, geothermal energy, tar sands and shale oil, and other exotica. Four dimensions of interdependence were considered in each of these cases: (a) economic issues and their political implications, (b) impact on terms of national security

and military strategy, (c) implications for global or regional community building, and (d) impacts upon the environment.

These are some brief illustrations of empirical findings based on recent work. There have been many drawbacks and many false starts and stops. But each stage drew upon the previous one and the progression from associations and correlations to causal modeling, simulation, and forecasting clearly represents a cumulative research effort. At the present time, the emerging focus on alternative forecasting methodologies, and on bringing them to bear upon our attempts to reduce uncertainties about the future, represents new directions of research. We now seek to develop reliable means of identifying the probabilities associated with alternative futures and policy interventions that might increase (or decrease) these probabilities.

#### FORECASTING IN INTERNATIONAL RELATIONS: A RESEARCH PROGRAM

Forecasting refers to the development of contingent and probabilistic statements regarding alternative future outcomes.<sup>4</sup> A successful forecast must account for (a) the direction of the activity modeled, (b) the direction of sharp breaks or reversals and the extent of change, (c) the period over which change is likely to persist, (d) the points in the system most amenable to manipulation and (e) the costs of policy interventions. The critical distinction between prediction and forecasting is one of contingencies and probabilities. A prediction usually dispenses with probabilistic interpretations; it is generally made in terms of a specific point or event. Forecasting, by contrast, focuses upon probabilities, contingent outcomes, and the specification of alternatives.

Forecasting in international relations is particularly challenging in view of the large number of variables in question, the magnitudes of the unknowns, and the propensities for random factors or exogenous shocks. All the methodological complexities associated with forecasting as such are compounded by the uncertainties of tomorrow's international realities.

<sup>4</sup>The following observations are based upon, and expand, the arguments in Choucri (1974a).



Forecasting forces us to think of *alternatives*. "Goods" and "bads" assume the same theoretical importance in a forecasting design: the distinction is imposed upon future realities by the motivations, preferences, and expectations of the forecaster. The major components of our research program in international relations forecasting include: (a) specifying the structure of the system to be forecasted; (b) identifying the role of theory; (c) comparing and experimenting with alternative forecasting methodologies; (d) delineating the different purposes and the different time horizons for alternative forecasts; (e) specifying the policy implications of forecasting and illustrating its relevance for the development of appropriate policy interventions; (f) systematically altering the values of key coefficients or variables to test the consequences of different policies; and (g) designing alternative futures and specifying the interventions needed *now* to realize alternative future designs.

Together, these seven issues have provided the foundation of an evolving approach to international relations forecasting.

So far we have completed two major empirically based forecasting studies in international relations. The first was designed to replicate the behavior of nations in conflict and to identify the policies that would have an impact upon the expansion of national behavior outside territorial boundaries as well as those that might reduce armament competition (Choucri and North, 1975). The strength of this study lies in a sound theoretical base, an empirically validated model of international conflict, a good simulation of system behavior, and some initial probes into the effect of alternative policies. However, the major effort has been in model building and simulation. The forecasting aspects of this study remain preliminary and tentative. In addition, its purpose was to examine the impact of alternative policies upon past behavior, raising the counterfactual "what if" query; systematic forecasts into the future, beyond known data, were not undertaken.

The second study was designed specifically to examine the impact of alternative policies on future behavior. Its purpose was to identify the extent to which national growth and economic development in the United States increase the

country's propensities for external expansion and conflict behavior. The model was validated against empirical data for 1930-1970 and alternative forecasts were undertaken to the year 2000. (The choice of a terminal date is arbitrary; our purpose was to examine the impact of alternative policies over a short, as well as long, range.) It represents a clear extension and elaboration of the first study, and an attempt to incorporate the earlier experience into a cumulative research perspective. Thus, while the earlier model of *Nations in Conflict* (Choucri and North, 1975) is designed as a system of simultaneous equations, with some feedback relations, the specifications in *The Determinants of Lateral Pressure* (Choucri and Bousfield, 1975) represent a system of nonlinear, dynamic, feedback loops specified as a complex process in which change is endogenous, determined by variables in the model and not by exogenous factors. Such a specification is a more complete representation of the processes modeled and poses a greater theoretical and methodological challenge than the earlier formulation. But it is a model of the internal determinants of external behavior and their implications for conflict; it does not take into account the interactions among nations. The modeling of these is clearly the next step.

These studies, and related efforts, have led to the adoption of ten theoretical and methodological requisites for forecasting in international relations:

1. a dynamic process-oriented approach to the substantive issues at hand;
2. an awareness of the implications of the choice of methodology for modeling and understanding the behavior of the system at hand;
3. a realization that the images of the future and the policy interventions selected are conditioned by prevailing assessments of the past and the present (a built-in regression toward the present need is to be consciously avoided in specifying the structure of the model);
4. systematic evaluations of what present trends are likely to produce if no interventions were undertaken, and specifications of the ranges of expected outcomes and (ideally) the probabilities associated with each;

5. a comparison of alternative research paradigms to evaluate their comparative relevance for modeling different aspects of international behavior (different methodologies are appropriate for different problems);
6. simulating the behavior of a system over the historical (known) past to articulate expectations regarding alternative futures, and systematically alternating the key coefficients and variables in a model to observe their impact on system behavior; and
7. specifying the alternative causal mechanisms underlying future outcomes articulating or identifying the different "paths" that could lead to the same (or alternative) futures;
8. adopting a multiperspective view of the issues modeled to test for the consequences of alternative political orientations;
9. articulating the values underlying different specifications of the system modeled; and finally,
10. systematically "importing" the future into the present by evaluating the implications for the present if certain futures were realized.

Together, these 10 directives have yielded the basic "rules" of an evolving research program in international relations forecasting. Research support from the National Science Foundation is enabling the systematic comparison of alternative forecasting methodologies for evaluating the consequences of resource constraints for the United States in international politics. As can be seen, considerable trial and error marked the development of a research strategy that had begun with correlation analyses of the determinants of violent conflict and is now centering around forecasting in international relations. The present investigations represent the latest stage in a cumulative research strategy.

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# In Search of Global Patterns

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