NATIONAL AND INTERNATIONAL SYSTEMS: A COMPUTER SIMULATION

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Rufus P. Browning
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ABSTRACT

NATIONAL AND INTERNATIONAL
SYSTEMS: A COMPUTER SIMULATION

by

Stuart Allan Bremer

This research entails the development and evaluation of a computer simulation model of some aspects of international relations. The model, the Simulated International ProcessER (SIPER) is an extension of the Inter-Nation Simulation (INS) model, a man-machine simulation. Decision-making participants have been replaced with sets of decision-making and information processing rules.

These rules generate a variety of national behavior including revolutions, resource allocation, trade, aid granting, and diplomatic conflict. Arms races, economic growth and stagnation, and conflict spirals are just a few of the emergent properties of the model.

Twenty-four five-nation international systems were created to evaluate the performance of the model. A series of hypotheses about the relationships between three attribute variables and fourteen behavior variables for real and simulated nations were tested. It was found that SIPER corresponds to the real world in about two-thirds of the relationships examined, while INS corresponds to the real

world in just under one-half of the relationships. It appears that the behavior of SIPER-generated nations better approximates the behavior of referent nations than does the behavior of INS-generated nations.

A comparison of some static, structural characteristics of SIPER, INS, and referent international systems suggests that the SIPER and INS systems correspond quite closely to the early nineteenth century European state system. Among contemporary referent systems, the correspondence for SIPER and INS systems is greatest with regard to developing systems.

A comparison of some dynamic characteristics of SIPER and referent international systems was done using different time scales. Applying a time scale where one period of simulated time equals one year of real time indicates that the magnitude of change in the SIPER systems is much greater than that which has characterized the Western community in recent years. Further study of situations where rapid social change is found in referent systems suggested that the simulated international systems have more in common with referent systems preparing for war than referent systems suffering from economic depression.

A time scale of one period of simulated time equal to one decade of real time yields better correspondence for the simulated systems and suggests that the model is better suited for generating long trends in behavior than short term variations.

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[illegible] electrical [illegible]

It was found, generally, that the model exhibits a tendency to produce too much international autarky, economic stagnation, and military escalation and suggestions are offered as to the future direction of research on eliminating these problems. In the balance, the SIPER model appears to be a viable one, yielding sufficient accuracy with respect to real world processes to warrant its continued extension and refinement.

It was found, generally, that the [illegible] exhibits a tendency to produce [illegible] [illegible] [illegible] [illegible], [illegible] [illegible], and [illegible] [illegible] and [illegible] the [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible]

NATIONAL AND INTERNATIONAL SYSTEMS:

A COMPUTER SIMULATION

By

Stuart Allan Bremer

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In a research project which borrows so heavily from the work of others, as this one does, those to whom acknowledgement is due grow so numerous as render the expression of gratitude an impossible task. Harold Guetzkow, Paul Smoker, and Rufus Browning have made special contributions, and I wish to express my appreciation to them. Finally I wish to thank my wife Marsha who, through her careful editing, is chiefly responsible for any expository merit this work may contain.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The research to be reported here entails the development and evaluation of a computer simulation model of international relations. The model has been named SIPER (Simulated International ProcessER) to acknowledge the generous support received from the Simulated International Processes project of Northwestern University and its director, Harold Guetzkow.

We think it profitable to review some of the factors that led us to undertake this research, for these will help to establish the context within which the research is to be viewed.

The Inter-Nation Simulation model, developed by Harold Guetzkow and his associates at Northwestern University,[1] played a major role in the development of the SIPER model. It is perhaps inappropriate to refer to the INS model in the singular. The work that has been done with the Inter-Nation Simulation has produced a family of models.

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[1] For a discussion of their early efforts see Harold Guetzkow, Chadwick F. Alger, Richard A. Brody, Robert C. Noel, and Richard C. Snyder, <u>Simulation in International Relations</u> (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963).

If we may be permitted to continue the analogy, we see three main blood lines emanating from the original work by Guetzkow. These blood lines correspond to the three fairly distinct purposes that the INS model has served: teaching, laboratory research, and testing and extension of the model itself.

In the first lineage we find the Guetzkow and Cherryholmes version,[2] the Skinner and Wells version,[3] and William Coplin's World Politics Simulation[4] to name just a few. Each of these efforts is directed at improving the initial INS model as a replicator of decision-makers' environments. Coplin, for example, has elaborated the internal aspects of the nation in an effort to more fully replicate the kinds of domestic pressures that are exerted on decision-makers. The primary objective in his efforts is to enhance for participants the realism of the simulation.

The second line of descent uses the INS to test in a laboratory setting certain types of experimental effects. These effects, such as nuclear proliferation, do not lend

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[2]Harold Guetzkow and Cleo H. Cherryholmes, Inter-Nation Simulation Kit (Chicago: Science Research Associates, Inc., 1966).

[3]Donald D. Skinner and Robert D. Wells, Jr., Michigan Inter-Nation Simulation (Ann Arbor: The Department of Political Science and The Center for Research on Learning and Teaching, The University of Michigan, 1965).

[4]William D. Coplin, World Politics Simulation, II (Detroit: Department of Political Science, Wayne State University, 1967).

If we may be permitted to continue the analogy, we see three main blood lines emanating from the original stock by Gustafson. These blood lines correspond to the three fairly distinct [illegible] the model has served: teaching, [illegible] extension of the model [illegible] themselves to more traditional methods. Variations in the INS model have been developed by Brody and Driver,[5] Hermann and Hermann,[6] Raser and Crow,[7] Meier and Stickgold,[8] and Burgess and Robinson.[9] The experiments using the INS model or one of its descendants are too numerous to recount, and their number continues to grow.

The third lineage, and one that this work is heir to, is concerned with the evaluation and extension of the INS model as a theory of international politics. Most notable

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[5]Richard A. Brody, "Some Systemic Effects of the Spread of Nuclear Weapons Technology: A Study through Simulation of a Multi-Nuclear Future," Journal of Conflict Resolution, Vol. VII, No. 4 (December, 1963), pp. 665-753. See also Michael J. Driver, "A Cognitive Structure Analysis of Agression, Stress, and Personality in an Inter-Nation Simulation" (Lafayette, Indiana: Purdue University, August, 1965).

[6]Charles F. Hermann and Margaret G. Hermann, "An Attempt to Simulate the Outbreak of World War I," American Political Science Review, Vol. LXI, No. 2 (June, 1967), pp. 400-416.

[7]John Raser and Wayman Crow, WINSAFE II: An Inter-Nation Simulation Embodying Capacity to Delay Response (La Jolla, Calif.: Western Behavioral Sciences Institute, July, 1964).

[8]Dorothy L. Meier and Arthur Stickgold, "Progress Report: Event Simulation Project-INS 16" (Evanston, Ill.: Simulated International Processes, Northwestern University, 1965).

[9]Philip Burgess and James Robinson, "Alliances and the Theory of Collective Action: A Simulation of Coalition Processes," in James N. Rosenau, ed., International Politics and Foreign Policy (New York: The Free Press, 1969), pp. 640-653.

in this regard is the work of Richard Chadwick,[10] Charles Elder and Robert Pendley,[11] and, of course, Paul Smoker.[12] The International Processes Simulation developed by Paul Smoker represents a quantum jump in the evolution of the Inter-Nation Simulation.

It would be misleading to suggest that there has not been interaction between these three lines of descent. The teachers, experimentalists and modelers have borrowed from one another, and in some cases it would be difficult to identify their primary roles. In the case of this research, we have used the experience gathered by participating in and running the Inter-Nation Simulation in a classroom context,

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[10] Richard W. Chadwick, "Developments in a Partial Theory of International Behavior: A Test and Extension of Inter-Nation Simulation Theory" (Evanston, Ill.: unpublished Ph.D. thesis, Department of Political Science, Northwestern University, 1966).

[11] Charles D. Elder and Robert E. Pendley, "Simulation as Theory Building in the Study of International Relations" (Evanston, Ill.: Simulated International Processes project, Northwestern University, July, 1966).

____________________, "An Analysis of Consumption Standards and Validation Satisfaction in the Inter-Nation Simulation in Terms of Contemporary Economic Theory and Data" (Evanston, Ill.: Simulated International Processes project, Northwestern University, November, 1966).

Robert E. Pendley and Charles D. Elder, "An Analysis of Office Holding in the Inter-Nation Simulation in Terms of Contemporary Political Theory and Data of the Stability of Regimes and Governments" (Evanston, Ill.: Simulated International Processes project, Northwestern University, November, 1966).

[12] Paul L. Smoker, "An International Processes Simulation: Theory and Description" (Evanston, Ill.: Simulated International Processes project, Northwestern University, 1968).

as well as the insight generated by the experimentalists and the extensive validation studies of the model itself.[13]

We think that this research, like Smoker's, represents a quantum jump in the evolution of the INS model. The two represent, however, in one fundamental sense, movements in different directions. Smoker, by extending the programmed aspects of the model, has greatly elaborated the national and international context within which participants are placed. This work seeks to program the previously unprogrammed aspects of the basic Inter-Nation Simulation and render the INS model a "complete" theory of international politics.

We do not wish to debate the virtues of man-machine versus all-machine simulation models.[14] We do not have sufficient information to make cost-benefit comparisons at this time. Our own experience suggests that computer models, compared to man-machine simulations, may be more costly, in time and money resources, in the development stage, but less

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[13]For an excellent summary discussion and bibliography of the validation of the INS model, see Harold Guetzkow, "Some Correspondences between Simulations and "Realities" in International Relations" in Morton A. Kaplan, ed., New Approaches to International Relations (New York, St. Martin's Press, 1968), pp. 202-269.

[14]For a comparison of three simulations, the Political-Military Exercise, the Inter-Nation Simulation, and the TEMPER computer simulation, see Hayward R. Alker, Jr. and Ronald D. Brunner, "Simulating International Conflict: A Comparison of Three Approaches," International Studies Quarterly, Vol. 13, No. 1 (March, 1969), pp. 70-110.

diverse [illegible] insight generated by the experimentalists and the extensive validation studies of the model results.[33]

[illegible]

costly once they reach maturity. The matter of benefits raises the larger question of the purpose of this research.

John Raser has described the motivation underlying the creation of "skeletal" simulations in the following way.

> The researcher does not try to narrow his focus to one small segment or aspect of human social behavior; instead he tries to simulate a large and complex system, such as 'international relations.' But he knows that he can not identify all the units or the relationships among them. So he selects those units and those relationships about which his information is greatest and, using them as a framework--as the 'bones'--he builds a skeleton of international relations. He hopes that by continually gathering more data in the field, by operating the simulation over and over and thus learning what is pertinent, he slowly will be able to flesh out the bones of his skeleton until someday he has a more complete simulation of the system in which he is interested. In the meantime, he must be aware that he has abstracted and cruelly abbreviated, that his simulation is to real life what a skeleton is to a living man.[15]

We feel that the all-computer mode of operation lends itself more readily to the incrementalist research strategy that Raser is talking about than does the man-machine mode of operation. The differences generated by a change in the model can be quickly observed and evaluated once the computer model has reached a certain level of maturity.

Moreover, Raser's comments are directed at the heart of the underlying rationale for the present research. Our ultimate objective is to create a computer simulation model of international relations with which we can study the dynamics of international systems. This objective can only

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[15] John R. Raser, Simulation and Society (Boston: Allyn and Bacon, Inc., 1969), pp. 27-28.

be attained in a slow, evolutionary fashion, and the method of computer simulation seems well suited to this.

The selection of an incrementalist research strategy explains, for the most part, why we chose to use an existing model, the Inter-Nation Simulation, as our point of departure rather than creating a totally new model like Technological, Economic, Military, and Political Evaluation Routine (TEMPER)[16] or Benson's "Simple Diplomatic Game."[17]

Our resources would not permit the creation of a model to rival TEMPER, and we feel that such an effort would be premature given our limited knowledge. According to Raser

> [TEMPER] has been defined as a completed simulation--it is in the hands of those who must justify its existence by immediate use in policy development rather than as a vehicle for its own improvement. It seems likely that TEMPER will remain in its present state and that its weaknesses will be permanent drawbacks rather than takeoff points for improvement as is the case with the INS, which remains in the hands of its builders as a dynamic research technique.[18]

Raser continues, "[A]ny social simulation effort is not going to achieve high structural isomorphism at its early stages; the pertinent question is whether its builders are

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[16]TEMPER: Technological, Economic, Military, and Political Evaluation Routine (Bedford, Mass.: Raytheon Company, Vol. 1-7, 1965-1966).

[17]Oliver Benson, "Simulation of International Relations and Diplomacy" in Harold Borko, ed., Computer Applications in the Behavioral Sciences (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962), pp. 574-595.

[18]Raser, op. cit., pp. 149-150.

placing their highest premium on a 'product' or on a process."[19]

The computer model which serves as the basis for this research is not complete in the sense that TEMPER is. At best it is a partial theory of international relations embodied in a form that is intelligible to a computer. On the other hand, it is a step up from Benson's model, and, all things considered, we see the SIPER model as one of the most complex and consistent theories of international relations in existence today.

As we see it, there is a strong need for the development of computer models which have predictive power with respect to international phenomena. Jay Forrester argues that complex systems are counter-intuitive.[20] By this he means that there is a strong tendency for choices which are based on experience gained from less complex systems to have the opposite effects from those intended. If this principle holds for the international system as well, it may be the case that complex computer simulation models offer us the only effective way of evaluating the long-term consequences of policy choices.

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[19] Ibid., p. 150.

[20] Jay Forrester, Urban Dynamics (Cambridge, Mass.: The MIT Press, 1969). Chapter 7, "Notes on the Nature of Complex Systems," is particularly informative.

We have tried to keep this introduction short, for the work itself is lengthy and complex. The next chapter presents the theory that the model embodies, and the following chapter indicates the parameter and variable settings that were used in the set of computer runs reported on in Chapters IV and V. Chapter VI is devoted to a discussion of the overall strengths and weaknesses of the model and the direction in which future research is to proceed. This is followed by an appendix containing the computer program and a glossary of terms frequently used.

We have tried to keep this introduction short, for the work itself is lengthy and complex. The next chapter presents the theory that the model embodies, and the following chapter investigates [illegible] variable [illegible] that were used in [illegible]

[illegible]

CHAPTER II

THE SIMULATION MODEL

The description of a complex model is always a difficult task, and to facilitate the understanding of this model, the description has been broken down into several sections.

Sections1 and 2 deal with some basic economic and political concepts and relationships. The substance presented in these sections is derived largely from the Inter-Nation Simulation model,[1] and the reader should thoroughly familiarize himself with these concepts and relationships before the later sections are attempted.

Section 3 is concerned with basic information processing rules in the model, and their centrality is such that a discussion of this subject seems warranted before the decision-making processes in sections 4, 5 and 6 are discussed.

The decision processes in these latter sections are described in the order that they are executed by a simulated nation in the course of one period of simulated time. With

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[1]See Harold Guetzkow, et al., Simulation in International Relations (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963), Chapter 5, "Structured Programs and their Relation to Free Activity within the Inter-Nation Simulation," pp. 103-149. This is particularly illuminating regarding the structure and process of the Inter-Nation Simulation model.

reference to the total time cycle the reader should bear in mind that the concepts and relationships discussed in sections 1 and 2 define both the state of the national system in the pre-decisional stage and the consequences for the national system in the post-decisional stage. The consequences of decisions made in time period T constitute the pre-decisional situation in period T+1, as is characteristic of iterative models.

Before beginning our description we should indicate some of the notational conventions that will be used in what follows. An effort has been made to allow the reader to refer to appropriate parts of the computer program contained in the appendix, and to facilitate this the relevant computer instruction numbers are contained in brackets where reference is appropriate. In the equations that follow T refers to the present period of time, I to the nation which is making the decisions, and J to a specific other nation which is the object of nation I's decision-making. In the case of multiply-subscripted variables, the first subscript is the source of action and the second is often the target of action.

We will follow two conventions with regard to parameters. Those which are found in equations derived from the INS model will be found in the footnotes, while those in sections 3 through 6 will be discussed further in Chapter III.

For ease of reference, a glossary of terms used in the model follows the appendix.

1. Basic Economic Concepts and Relationships

The economic system is Keynesian in nature in the sense that there are three sectors of economic activity: consumption, investment, and government. Consumption refers to that sector of economic activity which is concerned with the production of "final goods" with which "the population replenishes or increases its energies and ministers to its wants and needs...."[2] The value produced by this sector will be referred to as consumption satisfaction, or CS.

Investment refers to that sector of economic activity which is concerned with the production of value which has the characteristic of being able to produce more value.[3] We shall refer to this value as basic capability, or BC.

For our purposes the government sector will be equated with that aspect of economic activity which is concerned with the maintenance of the internal and external security of the system.[4] Other governmental economic activities are considered to be either consumption, such as government transfer payments, or investment, such as subsidies to industries. The value produced by activity in this sector has the characteristic of being able to destroy

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[2]Robert L. Heilbroner, Understanding Macro-Economics (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1968), p. 13.

[3]Ibid., p. 14.

[4]This assumption does not seem unreasonable since governments are typically defined as social institutions having a legal monopoly over the use of force.

other value. This will be called force capability, or FC.

Value production occurs when resources are allocated to an economic sector. These resources, the factors of production, are represented in the model by a unidimensional measure of resource capability, total basic capability, or TBC. Allocation to the investment sector increases the resource capability of the national system in the future; hence, total basic capability may be thought of as the accumulated past basic capability (BC) production.

The value produced by an allocation of TBC to an economic sector depends upon the size of that allocation and the efficiency of the economic sector. Each sector has a generation rate associated with it that states the output of the sector given a unit input of TBC. For example, the consumption satisfaction sector may have a generation rate of 1.4 for a particular nation, in which case an allocation of 100 TBC units will produce 140 units of CS value. Each nation has a set of three generation rates (CSGR, BCGR, FCGR), which may be considered analogous to what the economists call opportunity costs, and these rates will differ from nation to nation in response to their level of development and degree of specialization.

There is a second kind of value accumulation which occurs in the economic system. Force capability value accumulates in such a way that at least part of the value produced in the present time period will be available for use in a future time period. The storage area for force

capability is called total force capability (TFC), and the level of this variable determines the amount of force capability which can be used in defense of the system at any time.

These two value reservoirs, TBC and TFC, are assumed to depreciate. In other words, there is a flow from the reservoirs to entropy. Hence, to maintain constant levels, allocations to the investment and defense sectors are necessary. The rate of depreciation for TBC is either 2 per cent, 5 per cent, or 10 per cent, depending upon a stochastic determination in which each rate is given an equal probability of being used. The rates of depreciation for TFC are 20 per cent, 30 per cent, or 40 per cent, depending upon a stochastic determination as discussed above.

We can now establish some basic relationships in equation form. With regard to nation I at time T the amount of CS value produced is expressed as

$$CS(I,T) = CSP(I,T) * TBC(I,T) * CSGR(I), \qquad (1)$$

where CSP is the proportion of national resources allocated to consumption. Similarly the BC value produced is expressed as

$$BC(I,T) = BCP(I,T) * TBC(I,T) * BCGR(I), \qquad (2)$$

and the FC value produced is expressed as

$$FC(I,T) = FCP(I,T) * TBC(I,T) * FCGR(I). \qquad (3)$$

CS value is completely consumed, but BC and FC value accumulate in the following ways:

$$TBC(I,T+1) = TBC(I,T) + BC(I,T) - DBC(I,T) * TBC(I,T) \text{ and } \quad (4)$$

$$TFC(I,T+1) = TFC(I,T) + FC(I,T) - DFC(I,T) * TFC(I,T), \quad (5)$$

where DBC and DFC are the selected depreciation rates discussed earlier.

The setting of values for CSP, BCP and FCP constitute major decisions which have far ranging consequences for the simulated national systems, and it is to the nature of these consequences that we now turn our attention.

2. Basic Political Concepts and Relations

In the previous section we discussed a set of decisions concerned with the allocation of resources to the production of value. This set of decisions involves the authoritative allocation of value, which, according to Easton, is the domain of the political system.[5]

The making of decisions necessarily entails the existence of a set of decision-makers, and in this context the term decision-makers may be thought of as parallel to the concept of elite. Whether we consider them the "influential"

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[5]David Easton, A Framework for Political Analysis (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1965).

as Lasswell does,[6] or the "active population" as Rashevsky does,[7] "by an 'elite' we mean a very small (usually less than .5 per cent) minority of people who have very much more of at least one of the basic values than have the rest of the population...."[8] In an Eastonian sense our "decision-makers" are the authoritative allocators of the system.

In the previous section we specified that economic activity in the consumption sector produced value that was consumed by the "population." These consumers, which, in conformity with the INS model, we shall call validators, may be thought of as the masses or non-elite. We need not be concerned at this level of abstraction with the question of who is and who is not a member of the elite and therefore a "decision-maker." We need only postulate that the population of a nation can be divided up for analytical purposes into those who have more and those who have less control over the behavior of the nation.[9]

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[6]Harold D. Lasswell, "Introduction: The Study of Political Elites," in Harold D. Lasswell and Daniel Lerner, eds., World Revolutionary Elites (Cambridge, Mass.: The M.I.T. Press, 1965), pp. 4-6.

[7]Nicholas Rashevsky, Mathematical Theory of Human Relations: An Approach to a Mathematical Biology of Social Phenomena (Bloomington, Ind.: Principia Press, 1947), pp. 148-49.

[8]Karl W. Deutsch, The Analysis of International Relations (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1968), p. 63.

[9]Among the more recent works incorporating the distinction between elite and mass is Ted R. Gurr, Why Men Rebel (Princeton, N. J.: Princeton University Press, 1969).

We begin our discussion of the programmed relationships between the decision-makers and validators with a consideration of the demands which the validators make of the decision-makers. [H21-H38] The demands fall into two areas.

1) The validators expect a certain flow of CS value into their hands.

2) The validators expect a certain level of national security.

The specification of these demand functions follows the formulations used in the Inter-Nation Simulation.[10]

With regard to the first demand, let us assume the existance of a minimum level of CS value flow below which the nation cannot go without ceasing to exist. This may be thought of as the subsistance level or simply the maximum deprivation that the validators will endure. We will call this variable CSmin, and it is a function of the CS value production potential of the nation (CSmax). CSmax is in turn a function of the value productive resources of the nation, TBC, and the productivity of the consumption sector, CSGR.[11]

$$CSmax = TBC * CSGR \qquad (6)$$

The minimum CS value flow will be[12]

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[10]Guetzkow, *op. cit.*, pp. 122-127.

[11]*Ibid.*, p. 123.

[12]*Ibid.*, p. 124. The parameter K is conventionally set at 380,000.

$$CSmin = (1-CSmax/k) * CSmax \quad (7)$$

CSmax and CSmin represent the maximum and minimum demands of the validators with respect to CS value flow.

The validators give support to the decision-makers in response to the level of CS value flow at any point in time in relation to this minimum and maximum. This support is manifested in the variable of validator satisfaction with respect to consumption satisfaction, or VScs. As specified in the Inter-Nation Simulation, VScs is dependent on three factors.

1) For consumption near minimum consumption standards, validator satisfaction depends on the relation of consumption satisfaction to minimum consumption levels.
2) Once minimum consumption standards have been met, larger and larger increases in consumption are necessary to produce corresponding changes in validator satisfaction.
3) This saturation effect is more pronounced for wealthier nations.[13]

The formulation of this is as follows:[14]

$$VScs = 1 + r * (CS/CSmin-1) - v * CSmax/CSmin * (CS/CSmin-1)^2 \quad (8)$$

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[13] Ibid.

[14] Ibid., p. 125. The r and v parameters are conventionally set at 55.0 and 41.0, respectively.

In an aggregate sense, then, the support the validators give to the decision-makers is partially a function of the level of the CS value flow, the value productive resources of the nation, and the efficiency of the mechanisms that produce the CS value.

The second area of validator demands is national security. [H53-H70] Here we postulate that the validators expect a distribution of world force capability favorable to their national security, as well as a favorable distribution of potential force capability. The support the validators give to the decision-makers in response to the satisfaction of this demand is called validator satisfaction with respect to national security, or simply VSns. However, in determining the distribution of world force capability, the validators do not perceive internal coercive forces as factors in their decision. Since total force capability includes forces for the control of external and internal systemic threat, we want to remove the force capability devoted to internal control (FCic) from the support equation. That equation is[15]

$$VSns = w * \frac{\sum_{\text{allies}} (TFC - FCic + a'*TBC)}{\sum_{\text{non-allies}} (TFC - FCic + a'*TBC)} + b' \qquad (9)$$

The minimum value of VSns is 1.0, and the maximum is 10.0. A VSns of less than 1.0 indicates that the nation should be

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[15] Ibid., p. 126. The suggested values for w, a' and b' are 3.0, 0.5, and 1.3, respectively.

considered "disengaged from the armaments race,"[16] and a favorable balance of forces ceases to be a demand for the validators. In this case support is solely dependent on consumption flow.

The aggregate support for the decision-makers, called VSm, is a weighted average of the two support factors discussed above.[17] [H71-H73]

$$VSm = e * VScs + g * VSns \qquad (10)$$

It is clear that political systems differ in the degree to which decision-makers are dependent upon validator support for their continuation as decision-makers. The power to disregard the wishes of the validators is called decision latitude (DL).[18] Political systems with low decision latitude may be considered open,[19] flexible,[20] non-directive,[21] or accessible.[22] In any event, this may be considered a

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[16] Ibid., p. 127.

[17] Ibid., p. 114. The suggested values for weights e and g are both 0.5.

[18] Ibid., pp. 115-117.

[19] James N. Rosenau, "Pre-theories and Theories of Foreign Policy," in R. Barry Farrell, ed., Approaches to Comparative and International Politics (Evanston, Ill.: Northwestern University Press, 1966), pp. 27-92.

[20] Quincy Wright, The Study of International Relations (New York: Appleton-Century-Crofts, Inc., 1955), pp. 543-553.

[21] Morton A. Kaplan, System and Process in International Politics (New York: John Wiley & Sons, 1957), pp. 54-56.

[22] Phillip M. Gregg and Arthur S. Banks, "Dimensions of Political Systems: Factor Analysis of a Cross-Polity Survey," American Political Science Review, LIX (1965), pp. 602-614.

structural variable which mediates the relationship between the decision-makers and validators. [H74-H91]

Decision latitude is not necessarily constant. It is assumed that the validators will periodically seek to change the political system by making it more responsive to their wishes or demanding more leadership from the decision-makers. In the model, a unit increment in DL, a unit decrement in DL, and no change in DL are equally likely outcomes of a stochastic decision process in any given period of time. The variable DDL introduces random shocks into the relationship between the decision-makers and validators, to which the system must adapt.[23]

Returning now to the question of the relationship between the degree to which the validators are satisfied and the stability of the political system, we assume, as INS does, that[24]

$$POH = a * (b-DL) * VSm + c * (DL-d) \qquad (11)$$

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[23] In the original INS model, provision was made for the decision-makers to initiate increases in decision latitude. It was not included in this extension because an inspection of INS data indicated the option was seldom used by participants and it was thought desirable to simplify the model somewhat by its exclusion.

[24] Guetzkow, op. cit., p. 111. The suggested values for a, b, c, and d are 0.01, 11.0, 0.1, and 1.0 respectively.

POH, as it is used here, is a measure of the stability of the system, as suggested by Elder and Pendley.[25]

It will be recalled that in the VSns formulation, equation 9, there was a term FCic, or force capability devoted to internal control. The role of coercive forces in the control of internal threats to the political system is well established,[26] and it is assumed that the decision-makers will alot some proportion of their total force capability to the performance of this function. The importance of this force will become clear when we consider another way in which the validators may manifest their support or lack of support for the decision-makers.

Revolutions may occur in the simulated nations, and their occurrence is dependent on four factors. If the overall validator satisfaction, VSm, is above a revolution threshold, m, revolution is not considered possible.[27] If this threshold value is not reached, then the probability of revolution is dependent upon the nature of the political system and the level of coercive forces, in the following

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[25]Robert E. Pendley and Charles D. Elder, "An Analysis of Office-Holding in the Inter-Nation Simulation in Terms of Contemporary Political Theory and Data on the Stability of Regimes and Governments" (Evanston, Ill.: Simulated International Processes Project, Northwestern University, November, 1966).

[26]Gurr, _op_. _cit_.

[27]VSm varies from 1 to 10, and the revolution threshold was set at 3.

manner.[28]

$$PR = \frac{g' * DL - k' * (FCic/TFC) + 1}{h'}$$

The final decision as to whether a revolution occurs or not depends upon a stochastic decision process. Should a revolution occur, however, there are substantial costs to the national system. All force capability devoted to internal control (FCic) is considered lost in defense of the system. Furthermore, there are substantial losses in the productive capacity of the system; 20 per cent of the nation's total basic capability is assumed lost in the event of a revolution. On the other hand, there are benefits to be gained from a revolution in the form of momentary increases in the overall validator support. In the period following the revolution an increase in VSm of two units is credited and a one unit bonus is given in the period after that.[29]

It should be clear by now that we have described a set of conceptual variables that we may use to define the pre-decisional and post-decisional states of a simulated nation and a set of relationships which determine the transformation of the system given the outcome of the decisional stage. It is to this stage that we now turn our attention.

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[28] Guetzkow, op. cit., pp. 130-131. The parameters g', k', and h' were set at 0.1, 3.3, and 2.0 respectively. With these parameters the maximum ratio of FCic to TFC is 0.3.

[29] Ibid., pp. 131-132.

3. Basic Information Processing

In the following sections we will refer occasionally to the development of expectations by one nation as to the future behavior of another nation. In this section we will discuss how these estimates of future behavior are formulated.[30]

The central thesis of this section is that nations use information processing rules to forecast the behavior of other nations. Since much national behavior is, in part, anticipatory in nature, it is a matter of no small importance how future behavior is estimated. An underlying assumption of all the information processing rules to be discussed here is that the best estimate of future behavior is to be found in the analysis of past and present behavior. [B1-B60]

One of the simplest kinds of information processing rules involves the extension of the present into the future. For activity X, nation J's level of activity in the next time period, T+1, is

$$X(J,T+1) = X(J,T) \qquad (13)$$

This simple rule states that what is happening now is the best estimate of what will happen in the future. We have labeled this Rule 4.

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[30]This and the following sections have benefited from the work of Richard Cyert and James March, A Behavioral Theory of the Firm (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963) and Charles Bonini, Information Processing and Decision-Making in the Firm (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1967).

Rule 3 is a little more sophisticated in nature as it admits to the possibility of change, but change is viewed in a disjointed, incrementalist way.[31]

$$X(J,T+1) = X(J,T) + [X(J,T) - X(J,T-1)] \qquad (14)$$

In this rule the future level of behavior X for nation J is taken as the present level plus the last change in behavior. This rule is similar in many respects to the kinds of equations found in the Vietnam simulation model of Milstein and Mitchel.[32]

Information Rule 2, on the other hand, utilizes more past behavior than Rules 3 and 4, but, with regard to the expectation of change, it lies somewhere between the two. Rule 2 is

$$X(J,T+1) = \frac{\sum_{K=T-m}^{T} x(J,K)}{T-m+1} \qquad (15)$$

where m+1 indicates the number of time periods in the memory span.

Rule 1 is considerably more sophisticated than the previous rules. It is based on the conception that behavior

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[31]For a discussion of the disjointed incrementalist view see David Braybrooke and Charles E. Lindbloom, A Strategy of Decision (New York: The Free Press, 1963).

[32]See Jeffrey S. Milstein and William C. Mitchell, "A Quantitative Analysis and Predictive Computer Simulation," Peace Research Society (International) Papers, X (1968), pp. 161-213. They find that changes in behavior are often more significant than the absolute level of behavior.

over time manifests itself in the form of trends. The detection of these trends will enable the nation to estimate a future state. The rule is operationalized by the application of a linear regression of the past behavior on time. The rule states that

$$X(J,T+1) = a + b * (T+1) \tag{16}$$

where a and b are the constant and slope of the regression line estimated with the standard linear estimation procedures on values of X prior to T+1.

These four information processing rules are by no means exhaustive of the types of rules one could formulate, but they do represent the relevant aspects of two dimensions of information processing.

The first dimension is concerned with the expectation of change. If one presupposes his environment to be relatively stable, holding few surprises, then one would be led to formulate his expectations as to the future state of that environment in a different manner than if the presupposition is the opposite. The second dimension we think important here is concerned with the presupposition of a signal-to-noise ratio. If one has great faith in the information upon which estimates of future behavior are to be based, then, again, we would expect predictions to be rendered in a different fashion than if that information were felt to be unreliable. Figure 1 illustrates these two orthogonal dimensions.

FIGURE 1

DIMENSIONS OF INFORMATION PROCESSING

Environment
Presupposition

Stable

Rule 4:

$$X(J,T+1) = X(J,T)$$

Rule 2:

$$X(J,T+1) = \frac{\sum_{K=T-m}^{T} X(J,K)}{t-m+1}$$

Accurate

Approximate

Information
Presupposition

Rule 3:

$$X(J,T+1) = X(J,T) + [X(J,T) - X(J,T-1)]$$

Rule 1:

$$X(J,T+1) = a + b * (T+1)$$

Unstable

We have placed the information rules in the quadrants they are representative of. The use of Rule 4 presupposes the existence of a stable environment and accurate information since it entails the dual assumptions that future behavior will be the same as present behavior and that present behavior is known accurately. Rule 3 similarly assumes that past and present behavior are known with accuracy, but the constancy of behavior is not assumed. Rule 2, on the other hand, assumes just the opposite of Rule 3, as does Rule 1 make the opposite assumptions from Rule 4.

We will admit to one more rule which makes no binding presupposition about the stability of the environment or the quality of information it has to work with. This rule, Rule 0, may be considered the pragmatist's choice as it applies the criteria of what works best in the rendering of a forecast. Put in its simplest form, Rule 0 entails the use of that rule, among the four previously discussed, which hindsight suggests would have been the best one to use the last time behavior X was analyzed. Accordingly, the rule which best predicts the present level of behavior without the benefit of information about the present, is the one that is used to predict the future. Hence, we allow for the case where a nation may not constantly use the same rule when it becomes evident that there is a better one, and to this extent the nation is capable of learning and adapting with regard to forecasting.

ates in the quadrants

that correspond that

scores

The set of information processing rules is now complete. At the outset of a simulation run we can prescribe that all nations shall use the same rule or that each nation shall use a different rule. As we shall see, the set of simulation runs that will be reported on later involves only a limited exploration of the possible combinations of information rules.

4. National Goals

Nations are open, complex, adaptive systems and, as such, their behavior is purposive. Their behavior is intended to reduce the perceived discrepancy between the present state of the nation and some desired future state of the nation. We are concerned here with the national definition of that desirable future state.

To define completely the state of a complex system, be it present or future, we would need a very large number of dimensions. Theory and prudence inform us, however, that it is essential that we carefully select a subset of these dimensions for scrutiny.

The first goal area to be so isolated is political stability. Decision-making elites have as a major goal of their behavior the retention of their decision-making positions. The elites will endeavor to use the resources of the political and economic systems they command to make their positions of command secure. This can, of course, have far ranging consequences. As Robert North pointed out,

> During the summer of 1914...the Austro-Hungarian leadership, feeling threatened by the spectre of Pan-Slavism, put forward the preservation of the dual Monarchy at all costs as their major policy goal.[33]

The second goal area that will guide the behavior of the decision-making elite of a nation is economic growth. The expansion of national productive capability has, particularly in this century, been a major objective. Organski has stated, "wealth is [a] goal that is sought to some extent by every nation."[34]

The third end toward which national behavior is directed is national security. By this we mean that nations act to further the continuation of their existance in the face of real or imagined external threats. As Raymond Aron has noted,

> Each political unit aspires to survive. Leaders and led are integrated in and eager to maintain the collectivity they constitute together by virtue of history, race or fortune.[35]

Political stability, economic growth, and national security by no means constitute an exclusive set of national objectives. They are, however, quite universal among nations and clearly prominent in the literature of international relations.

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[33]Robert C. North, "Decision-making in Crisis: An Introduction," Journal of Conflict Resolution, VI, No. 3 (September, 1962), p. 198.

[34]A. F. K. Organski, World Politics (New York: Alfred A. Knopf, 1958), p. 57.

[35]Raymond Aron, Peace and War (New York: Praeger, 1967), p. 72.

Our task of specifying the goals that guide nations is far from complete, however. Singer has stated;

> ...goals and motivations are both dependent and independent variables, and if we intend to explain a nation's foreign policy, we cannot settle for the mere postulation of these goals; we are compelled to go back a step and inquire into their genesis and the process by which they become the crucial variables that they seem to be in the behavior of nations.[36]

In specifying the process by which goals are set and reset we have relied heavily on the work of Richard M. Cyert and James G. March.[37] Their formulation of goal determination in the firm suggests a pattern for such behavior in all complex organizations, including nation-states.

Organizations set levels of aspiration in areas of meaningful achievement, and in the short run seek to attain these levels. In the long run, however, these aspiration levels themselves are subject to change. The result of this process is a dynamic homeostatic equilibrium of aspiration and achievement. In what follows we will show how this formulation is applied in the political stability and economic growth goal areas.

The Goal of Political Stability

We have posited that decision-makers act to make their positions secure. The degree of security they seek at any

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[36] J. David Singer, "The Level-of-Analysis Problem in International Relations" in Klaus Knorr and Sidney Verba, eds., _The International System: Theoretical Essays_ (Princeton, N. J.: Princeton University Press, 1961), p. 86.

[37] Richard Cyert and James March, _op_. _cit_., pp. 26-43.

given time we will call the nation's aspiration level for political stability (ALPOH). The current value of the aspiration level for political stability is dependent upon three factors: [C20-C30]

1) The past aspiration level for political stability.

2) The degree to which the past aspiration was achieved.

3) The achievement of a significant other with regard to political stability relative to one's own achievement.

The relevant equation is,

$$\begin{aligned} ALPOH(I,T) = {} & ALPI * ALPOH(I,T-1) \\ & + ALPA * [POH(I,T)-ALPOH(I,T-1)] \\ & + ALPE * [POH(K,T)-POH(I,T)] \end{aligned} \qquad (12)$$

The first term embodies the assumption that goals change slowly and incrementally. Culture and tradition are inertia-generating forces, and the coefficient ALPI, aspiration level for POH inertia, indicates the influence that such societal factors have over the modification of goals.

The second term is an adaptive or learning component in the formulation. It is a simple feedback loop with ALPA being the rate of adaptation. The coefficient is positive, hence over-achievement leads to a higher aspiration level and under-achievement leads to a lower one. The relationship between under-achievement and over-achievement is not

symmetrical, however.

We shall assume that nations will more readily raise their aspiration levels given encouragement and more reluctantly lower them when failure is encountered. This asymmetrical adaptation is expressed in the following way.

If POH is less than ALPOH, ALPA = ALPA/ALPAAS;
otherwise ALPA = ALPA. (18)

The coefficient of asymmetrical adaptation, ALPAAS, is assumed to be greater than one.

The third component of the above equation is a demonstration effect. That is, it is assumed that the achievement of significant others with regard to political stability in relation to one's own achievement will condition the aspiration level. The coefficient, ALPE, may be considered the propensity to emulate. Since its value is assumed to be greater than zero, the aspiration level of a nation will be increased by the attainment of a higher level of political stability by another nation deemed significant.

Nation K, the significant other, is chosen on the basis of similarity of resource capability. The nation which is most like the self nation with regard to resource capability will be selected for comparison.

The Goal of Economic Growth

The aspiration level for economic growth (ALGRO) is assumed to operate in the same manner as the aspiration level

for political stability. [C31-C34] The relevant equation is;

$$ALGRO(I,T) = ALGI * ALGRO(I,T-1) + ALGA * [PDTBC(I,T)-ALGRO(I,T-1)] + ALGE [PDTBC(K,T)-PDTBC(I,T)] \quad (19)$$

where PDTBC is the rate of growth in resource capability, TBC. The interpretation of the components and coefficients is exactly the same as above. There is also an asymmetrical adaptation coefficient, ALGAAS, and the significant other nation, K, is selected using the criteria outlined above.

The Goal of National Security

Before we discuss the process by which nations set their aspiration levels for national security, it is essential that we examine the way in which the international system is structured and stratified.

Nations are assumed to be grouped into alliances. The model as it presently stands does not allow for the position of non-alignment. Furthermore, the international system is bipolar in nature, with a major power functioning as the leader or dominant member in each alliance. The perspectives of alliance leaders and alliance members are sufficiently different that their behavior with regard to national security questions deserves separate treatment.

However, there are some common elements in their decision processes. National security is identified with

the ability to successfully counter the use of coercion by other nations. Hence when we speak of the aspiration level for national security, for both leaders and members, we will be referring to the level of defense that is considered adequate to counter external threat.

We have modified Singer's now classic threat equation since national goal setting behavior is anticipatory in nature, i.e., the national desire is to be able to counter not simply present threat, but also future threat. Accordingly, our formulation equates expected threat to the product of expected intent and expected capability.[38] In section 3 we discussed specifically how these expectations are arrived at in the model.

When a nation scans it's environment for possible threats to its security, it must be selective in its search pattern. The limitations of time and resources prevent the nation from treating all nations as potentially equally threatening. In the present model a simulated nation assumes that those nations in the international system with whom they have not entered into mutual security agreements are potentially threatening. The alliance structure serves as a guide to simplify the search for enemies.

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[38] J. David Singer, "Threat-perception and the Armament-Tension Dilemma," Journal of Conflict Resolution, II,1 (1958), pp. 90-105.

The Alliance Leader

When the leader of an alliance ponders the question of national security, [C35-C66] the nation perceives the question in terms of bloc security. As the leader of a bloc the nation takes upon itself the duty of evaluating the security position of its alliance vis à vis an opposing alliance. Leadership confers larger responsibilities than membership, and the security interests of the leader become intertwined with those of the group. Accordingly, the goal of national security merges with the goal of bloc security.

The gap that the alliance leader watches closely, then, is the difference between the amount of threat expected from the opposing bloc and the amount of threat-countering ability which his own bloc will have in the future.[39] If the bloc's counter-threat capability will be adequate, then the alliance leader will be content with its current defense commitments and those of its allies. If, on the other hand, the counter-threat capability is not judged adequate, then a revision of alliance security policy will be sought. We will elaborate this more fully.

Above we noted that nations were sensitive to expected threat, and we mentioned that expected threat was equal to

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[39] Our formulation here is essentially like the Lagerstrom-North anticipated-gap model. See Richard P. Lagerstrom and Robert C. North, "An Anticipated-Gap, Mathematical Model of International Dynamics" (Stanford, Cal.: Institute of Political Studies, Stanford University, April, 1969).

the product of expected intent and expected capability. One of the differences between alliance leaders and alliance members is their estimate of expected intentions. Intent in the threat calculation may be considered the probability that a given nation's force capability will be used against one's own nation, or it may be considered the proportion of a given nation's force capability that will be used against one's own nation. Another formulation might specify that expected intent is equal to the product of the expected probability of attack and the expected size of the attack, expressed as a proportion of the attacking nation's total force capability. In any case, it seems worthwhile to set the upper bound of intent at 1.0 and the lower bound at 0.0.

The assumption in the case of alliance leaders is that expected intent is always at the maximum value of 1.0. The reasons for this are several. It is assumed that the special responsibilities of leadership make a nation more cautious in its security calculations, and therefore it is likely to want to be able to counter the worst of all possible situations. It can do so, in part, because of its larger resource base and the associated consequence of being able to work with such a pessimistic view without being overwhelmed. And, of course, there is some realism contained in the special paranoia of alliance leaders. Their prominence and centrality in the international system make them primary targets for other nations.

The calculations that an alliance leader makes are as follows. The amount of threat the opposing alliance is likely to present in the next time period (OPOW) is

$$OPOW = \sum_{j=\text{non-allies}} TFC(J,T+1) \qquad (20)$$

The expected value of TFC(J,T+1) is given by the application of one of the information processing rules described in section 3 to data concerning nation J's past behavior with regard to total force capability levels.

The counter-threat capability (APOW) of the leader's own alliance is

$$APOW = TFC(I,T+1) + \sum_{j=\text{allies}} TFC(J,T+1) \qquad (21)$$

If APOW is greater than OPOW, then the leader's aspiration level for national security (ALSEC) will remain unchanged. If this relationship does not hold, then a series of steps are undertaken to formulate a defense policy for the alliance that will close the gap.

The leader first considers the amount by which the alliance, as a whole, must increase its military strength to counter the expected threat. The leader then computes the share of the increase that each ally should contribute based on its resource capability. The leader then modifies its aspiration level for national security in accordance with what it considers its fair share of the additional defense burden. In addition, it transmits cues (FCCUE) to

its allies suggesting to them what would be an appropriate level of defense allocation. This completes the determination of the aspiration level for an alliance leader.

The Alliance Member

The alliance member, like the alliance leader, reacts to the expectation of threat. [C67-C113] For the most part, however, the member cannot afford to assume the worst, and it is not so much concerned about the security of the bloc as its own security. These and other factors compel the alliance member to be more discriminating in its assessment of threat. To do so, the alliance member examines the verbal conflict behavior (HOST) of each non-allied nation to make estimates as to the future intentions of these nations. The expected threat (AD) is computed in the following way.

$$AD = \sum_{j=\text{non-allies}} ALSID * HOST(J,T,T+1) * TFC(J,T+1) \quad (22)$$

where TFC has the same meaning as above, and HOST(J,I,T+1) is the amount of verbal hostility that nation I expects to receive from nation J in the next time period. ALSID is a parameter which indicates the propensity to discount verbal statements when estimating intentions.

The value AD is our estimate of what level of force capability the nation would need in order to give itself reasonable unilateral protection. This value is then converted into units indicating what proportion of the national

resources would have to be allocated to defense in order to match this threat.

The alliance member now has two estimates as to what it should allocate to defense. Previously it has received a cue (FCCUE) from its alliance leader suggesting a certain level of armaments which would be appropriate according to the leader's assessment of the world situation. The member also has its own estimate based on his own observations of the world.

Reconciling these views and setting a national security aspiration level can occur in one of two ways. If the leader's estimate is less than or equal to the member's own estimate, then the member acquiesces and accepts the leader's policy. If, on the other hand, the alliance leader's estimate is more pessimistic than the member's and the leader's estimate is greater than the member's, a negotiation process is begun, the outcome of which is determined in the following way.

The outcome of the negotiation process is dependent upon the amount of power that the leader exercises over the member at the time of the negotiation. Etzioni identified three basic types of power in his discussion of political integration.[40] These are utilitarian or economic power, identive or ideological power, and coercive or military power.

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[40]Amitai Etzioni, Political Unification (New York: Holt, Rinehart and Winston, 1965).

Working with this power typology Denis Forcese found that only the first two of these were effective in coordinating the behavior of alliance leaders and members.[41] Forcese's findings were based largely on data generated by the Inter-Nation Simulation model. We have made the outcome of the bargaining process dependent upon the amount of utilitarian and identive power that the leader exercises over the member.

Utilitarian power (UPOW) is defined here as the degree to which the member is economically dependent upon the leader. UPOW varies from 0 to 1.0 and is computed in the following way.

$$UPOW = \frac{\sum_{K=1}^{T} TRADE(IL,I,K) + AID(IL,I,K)}{\sum_{K=1}^{T} \sum_{J=1}^{N} TRADE(J,I,K) + AID(J,I,K)} \qquad (23)$$

where T is the current time period, N is the number of nations in the international system, IL is the leader of the member's alliance, and TRADE(i,j,k) and AID(i,j,k) are the amounts of trade and aid sent to nation j by nation i in time period k.

Identive power reflects a kind of moral suasion that an alliance leader can exert by the manipulation of symbolic rewards. We postulate first that the greater the ideological difference between leader and member, the less identive power

[41] Denis Forcese, "Power and Military Alliance Cohesion" (St. Louis, Mo.: unpublished Ph.D. thesis, Department of Sociology, Washington University, 1968).

the leader will be able to exercise over the member. Consequently our preliminary formulation of identive power is:

$$IPOW = 1. - \left| \frac{DL(I,T)-DL(IL,T)}{DL(I,T)+DL(IL,T)} \right| \qquad (24)$$

IPOW varies from 0 to 1.0, and IL is member I's alliance leader. DL is, as we stated earlier, decision latitude.

It is felt, however, that identive power will be maximally effective when the world is ideologically polarized and less effective as perfect polarization is departed from. Consequently IPOW is modified by a term which takes into account the degree of polarization. Perfect polarization is defined as one-half of the nations on each end of the decision latitude continuum. This distribution gives maximum variance, and it is the standard deviation of this distribution which we use to quantify perfect polarization. The actual polarization is defined as the standard deviation of the distribution of decision latitude values among the nations in the international system. Hence our effectiveness measure is

$$IEFCT = \frac{\sqrt{\dfrac{\sum_{I=1}^{N} [DL(I,T) - DL(T)]^2}{N}}}{\left[\dfrac{N-1}{2} + .5\right] * \dfrac{5.4}{N} + \left[\dfrac{N}{2} + .5\right] * \dfrac{3.6}{N}} \qquad (25)$$

where N is the number of nations. This produces a value between 0 and 1.0 which indicates how polarized the world is.

Finally, IPOW is modified in the following fashion.

$$IPOW = IPOW * IEFCT \qquad (26)$$

IPOW still ranges from 0 to 1.0.

The compromise that is forged between the alliance leader and member, if only tacitly, is based upon the average of IPOW and UPOW in the following manner.

$$ALSEC(I,T) = ALSEC(I,T) + [FCCUE(IL,I)-ALSEC(I,T)]*[\frac{UPOW+IPOW}{2}] \qquad (27)$$

Consequently if leader IL had absolute power over member I (UPOW and IPOW equal to 1.0), member I would raise its own estimate of security needs, ALSEC(I,T), to the level, FCCUE (IL,I), suggested by its leader. Proportionately less power means proportionately less increase.

At this point we have completed the setting of aspiration levels for the simulated nations. We now turn to the consideration of how these aspiration levels are to be attained.

5. Goal Attainment and International Trade

At this stage each nation has a set of aspiration levels it wishes to attain. The next thing the simulated nation does is to operationalize these goals in terms of laying out a tentative resource allocation budget. [C115-C131] It makes preliminary estimates as to what proportion of its resources will have to go to consumer goods (CSP) to achieve

its aspiration level for political stability (ALPOH) in the following way.

$$CSP(I,T) = CSP(I,T-1) + ALPOR * (ALPOH(I,T)-POH(I,T)) * CSP(I,T-1) + ECAF * PR(I,T) \quad (28)$$

The first term embodies the idea that such decisions are incremental in nature, and the second states that the amount of revision is related to the degree that goal achievement has failed in the past. The third term causes the system to react when political stability is threatened by crisis. Parameter ALPOR is the goal operationalization rate and ECAF represents the propensity of the regime to react to a crisis of support by acceding to the validator's wishes with an emergency CS allocation.

The proportion of resources needed to achieve the growth aspiration level, ALGRO, is called BCP and is given by a similar equation.

$$BCP(I,T) = BCP(I,T-1) + ALGOR * (ALGRO(I,T)-PDTBC(I,T)) * BCP(I,T-1) \quad (29)$$

PDTBC(I,T) is the proportionate change in total basic capability from time T-1 to the present time T.

Because of the way in which the aspiration level for national security was computed, the estimated proportion of resources needed for defense (FCP) is already known. Hence,

$$FCP(I,T) = ALSEC(I,T) \quad (30)$$

The remaining allocation decision involves the establishment of the proportion of current total force capability (TFC) that will be used for internal control (FICP).

$$FICP(I,T) = FICP(I,T-1) + .3 * PR(I,T) \qquad (31)$$

The maximum vale of FICP is .30, as it is in the Inter-Nation Simulation model.

These four calculations complete the preliminary goal attainment decisions of the simulated nations. The decisions represent the systems' efforts to unilaterally fulfill their goal requirements, however they do not constitute the systems' final efforts.

Another major alternative open to the national system is that of exchanging goods with other systems. Accordingly, the nation next explores the possibility of profitably engaging in international trade.

International trade entails certain non-economic costs which we will call sovereignty costs. The kind of costs referred to here have been alluded to by Keynes.

> Let goods be home-spun wherever it is reasonably and conveniently possible....We do not wish...to be at the mercy of world forces....We wish to be our own masters, and to be as free as we can make ourselves from the interferences of the outside world.[42]

Jan Pen concluded, "...nationalism leads to protection, the deliberate choking-off of imports with the intention of

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[42]John Maynard Keynes as cited in Jan Pen, A Primer of International Trade (New York: Vintage Books, 1966), p. 93.

reserving the home market for home producers."[43] The methods which nations use to accomplish this are import duties, quotas, excise taxes, manipulation of public health and administrative rules, government purchase restrictions, import permits, and, of course, the state trading monopoly.

The simulated nations set import limits for each of the three kinds of goods. [C132-C138] These import limits (IMLIM) are a function of the size of the national economy and the particular priority that a given good has in the tentative allocation mix. The import limit on all imports (TOTIM) is

$$\text{TOTIM} = \text{ITAF} * \text{TBC(I,T)} \tag{32}$$

where ITAF is the international trade autarky factor, or propensity to import. The import limit for a specific good, such as BC's, a type 2 commodity, would be

$$\text{IMLIM(I,2)} = \frac{\text{BCP(I,T)}}{\text{CSP(I,T)-CSMF(I)+BCP(I,T)+FCP(I,T)}} * \text{TOTIM} \tag{33}$$

where CSMF(I) is the proportion of national resources that must be allocated to the CS sector to satisfy the CSmin requirement.

In addition to deciding in the preliminary trading stage how many foreign goods will be allowed to enter the nation, the nation must also decide the prices at which it is

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[43] *Ibid.*, p. 94.

willing to sell its goods to other nations. The national set of export prices (EXPRC) is a function of a series of factors. [C139-C158]

The basic unbiased price, or what might be considered the equal profit price, is given by the following formula.

$$EXPRC(I,J,K,L) = \frac{GR(J,L)*GR(I,L)*[GR(I,K)+GR(J,K)]}{GR(I,K)*GR(J,K)*[GR(I,L)+GR(J,L)]} \quad (34)$$

This formula states the amount of good L that nation I would want from nation J in exchange for one unit of good K. GR(I,1), GR(I,2), and GR(I,3) are nation I's generation rates for CS, BC, and FC goods respectively. The terms of trade given by this formula are such that nation I and J would derive an equal amount of profit by concluding a trade on these terms.

The fifty-fifty profit split appears to be a powerful norm in human interaction. Simmel, Durkheim, Homans, and Schelling are just a few of the authors who have noted is prominence.[44] In referring to the INS trade negotiations, Sherman commented, "these findings demonstrate the pervasiveness and importance of the fifty-fifty profit splitting norm for the prediction of the negotiation outcome."[45]

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[44]Georg Simmel, The Sociology of Georg Simmel, trans. and ed. Kurt H. Wolf (Glencoe, Ill.: Free Press, 1950). Emile Durkheim, Professional Ethics and Civic Morals (London: Routledge and Paul, 1957). George C. Homans, Social Behavior: Its Elementary Forms (New York: Harcourt, Brace and World, 1961). Thomas C. Schelling, The Strategy of Conflict (Cambridge, Mass.: Harvard University Press, 1960).

[45]Allen W. Sherman, "The Social Psychology of Bilateral Negotiations" (unpublished Masters dissertation, Department of Sociology, Northwestern University, 1963), p. 47.

On the other hand, we have reason to suspect that there are factors which produce a departure from the equal profit price. The first we shall consider is the preference among allies for trading with one another.

If we may define alliances as formal agreements to be responsive to one another, then we may postulate that this general state of responsiveness will lead allies to reduce their export prices to one another. Furthermore, it is reasonable to suggest that allies frequently interact and negotiate on a wide range of matters, and consequently the costs of trading are reduced.[46] By the same reasoning the costs of trading with nations that are not frequently interacted with, and to which one is not responsive, are higher. Consequently, EXPRC is modified in the following way.

$$EXPRC(I,J,K,L) = EXPRC(I,J,K,L) - APPF * (2*ALLY(I,J)-1) *EXPRC(I,J,K,L) \qquad (35)$$

where ALLY(I,J) equals 1 if I and J are allies and 0 otherwise. APPF is the alliance preference pricing factor, or, alternately, the price increase, expressed as a proportion, that a non-ally receives.

Yet another factor in setting export prices is the relative economic strengths of the two nations involved.

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[46] See Dean G. Pruitt, "An Analysis of Responsiveness between Nations," Journal of Conflict Resolution, VI,1 (March, 1962), pp. 5-18, for a discussion of the effects of frequent interaction between nations.

here are, of course, two ways that this can manifest itself. he UNCTAD version is that richer nations charge poorer ations more than they do other richer nations and are able o exploit poorer countries in this way. The opposite, or ATT, version, suggests that what Sherman observed in the NS trading patterns occurs in the real world. That is, a paternalistic attitude toward the smaller under-developed ountries" on the part of larger countries.[47] The consequence of this would be richer nations charging poorer ations less than other richer nations. Both of these facors are embodied in the following modification of EXPRC.

$$EXPRC(I,J,K,L) = EXPRC(I,J,K,L) + ESPF * \left[\frac{TBC(J,T)}{TBC(J,T)+TBC(I,T)} - .5\right] * EXPRC(I,J,K,L) \qquad (36)$$

 ESPF, the economic strength pricing factor, is greater an zero, then export prices are adjusted to the ability pay in such a way as to benefit poorer nations. If, on e other hand, ESPF is less than zero, trade prices are ased in favor of the wealthier nations.

The final factor which may enter into pricing decisions that of risk. One of the fundamental principles upon which ade is based is trust. International trade involves two nds of risks for the nation involved. The first is that it

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[47] Sherman, op. cit., p. 32.

ulfill its part of the bargain and the other nation
ıot. Trading is never a simultaneous exchange, and
isks involved require compensation. The second, more
ect, form of risk is that associated with the uncertainty
; knowing whether the goods you sell will not directly
lirectly inable the buyer to act contrary to your
ests at some future time. Trading-with-the-enemy
.ation is merely one form that this type of trade dis-
ıation can take. The objective of this factor is to
ıse the profit derived from trading with a hostile or
ısted nation in order to compensate for the increased
[48] Accordingly, the EXPRC is further modified.

$$I,J,K,L) = EXPRC(I,J,K,L) + IRPF * \frac{HOST(I,J,T)}{\sum_{K=1}^{N} HOST(I,K,T)} *$$

$$\left[\sum_{K=1}^{N} HOST(I,K,T) + 1\right] * EXPRC(I,J,K,L) \qquad (37)$$

,J,T) represents the hostile feelings that nation I
for nation J at time T. The first devision term
s relative hostility, or the degree to which it is
trated, and the log term relates this to the total
of hostility.

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[48] For a recent discussion of the effects of hostility
de see Richard E. Gift, "Trading in a Threat System:
S.-Soviet Case," Journal of Conflict Resolution, XIII, 4
ber, 1969), pp. 418-437.

This completes the setting of export prices for the
lated nations. The actual trading may now begin. [D1-
] The trading process itself begins with each nation
uting the foreign and domestic prices for each commodity,
preparing a list of profitable trades, which is rank-
red by profitability. A trade round consists of each
on making a bid to trade a specific commodity to another
ific nation for another specific commodity. After each
on has bid its most profitable trade a check is made to
.f any trade offers have been reciprocated. If this is
he case, then a new trade round is begun and the nations
or their next most profitable trade. This again is
wed by a reciprocity check, but this check includes bids
in both the first and second rounds. Trade rounds
nue until all nations except one have either reached
import limit and/or have no profitable trades yet to
When this state is reached trade ceases.

The reciprocation of bids entails the agreement on the
of trade, and it is only the actual quantities that
n to be determined. This is done by taking the smaller
e two import limits involved and basing the quantity
ion on this. The quantities thus exchanged are sub-
ed off the import limits of the two nations involved,
ne trading continues.

oal Attainment, International Aid, and Diplomatic Conflict

At this stage of the decision-making process the nation
plored the two major avenues of goal achievement open

t. The avenues of self-fulfillment and exchange-fulfill- are both attractive since they require compromising the grity of the national system in only small ways. Another rnative, requesting aid, involves a greater compromise ne national integrity and is chosen only when the nation s itself in a serious situation.

It is at this stage that the nations begin to evaluate r overall position with reference to all goal areas. to this point, activity in each goal area was carried on endently from activity in the other goal areas. The em of goal conflict is considered at this point, and a ution of any such conflict is sought.

Before this evaluation can take place, however, the n must adjust its allocation decisions in accordance any trade commitments that may have been made. [E21-E52] process involves the shifting of resources into sectors export commitments have been made, away from sectors import commitments have been received. Consequently alues for CSP, BCP, and FCP, the tentative proportional ation decisions, may require some adjustment.

The nation, at this point, considers the possibility it may have over-extended itself. [E53-E58] If the f CSP, BCP, and FCP is greater than one, the nation is with a deficit and a budget crisis. In the event of situation, the following processes are activated to ve the crisis. [E59-E76]

First, a new emergency budget is drafted based on two s: the size of the commitment that has been made in ector as indicated by the tentative proportional tion decisions, and the national priority for each . This latter set of values, which may be considered -crisis-resolution weights, indicate in a critical ion the degree of importance that is ascribed to each . Accordingly, the revised CS allocation would be

$$T) = \frac{PSPRI*CSP(I,T)}{PSPRI*CSP(I,T) + EGPRI*BCP(I,T) + NSPRI*FCP(I,T)} \quad (38)$$

PSPRI is the relative priority assigned to the area of cal stability. The new values for BCP and FCP are ated in an analogous way with EGPRI and NSPRI indicating lative priorities of economic growth and national ty. The nation now has a budget that is acceptable but cessarily desirable in terms of its consequences.

The nation may find, for example, that the level of ption flow that will result, after adding CS to be ed and subtracting CS to be exported, is far short of t feels it needs to achieve its aspiration level for cal stability. It may, under these circumstances, make est for a grant of CS value from another nation in the ational system. [E127-E138]

There are, however, some basic rules constraining s in making aid requests. We may, at some future time, o relax some of these constraints, but for the moment

are considered necessary simplifications.

The first of these provides that alliance leaders may make aid requests. Such requests would compromise their tion of authority and undermine their prominence in r alliance. Alliance members, on the other hand, when require aid, direct their requests only to the leader heir alliance. This is a constraint that we reluctantly se and resolve to relax in the future.

Within these constraints a nation requests aid of ific commodities to the degree that its prior considera- s revealed a discrepancy between the value level needed chieve a goal and the value level that is expected as a equence of fulfilling budget decisions.

An alliance leader, then, may be confronted with a number of aid requests, and the rendering of decisions rning these requests proceeds in the following manner. F117] There are four factors which exert control over ranting-of-aid decisions. First consideration is given e leader's economic ability to fulfill the aid requests s received. If the leader has found that it can meet spiration levels and have uncommited resources remaining, ll consider aid requests. If not, any aid requests it eceived will be ignored. [F21-F36] If, on the other the leader's surplus is sufficient such that all aid sts may be granted without sacrificing the attainment of wn goals, it will grant all requests.

In the event of a situation where the leader has a lus, but this surplus is not adequate to satisfy all the requests, the leader must decide how much and to whom will be given. There are three criteria that a leader to make such decisions.

The first consideration for the leader is the degree to n the requesting nation's economy and its own are inter-ndent. [F38-F50] The greater the economic linkages en the two nations, the greater the share of available resources the aid requesting nation will receive. The mic linkage with nation J, TF(J), is

$$TF(J) = \frac{\sum_{K=1}^{T} TRADE(J,I,K)}{\sum_{L=1}^{N} \sum_{K=1}^{T} TRADE(J,L,K)} \qquad (39)$$

T is the present period, N is the number of nations in ystem, and TRADE(i,j,k) is the exports of nation i to n j in period k. TF(J), which varies from 0 to 1.0, ates the degree to which nation J, the aid requesting n, has concentrated its trade with nation I, its alliance r.

The second consideration of the alliance leader is the to which the aid-requesting ally has followed its tions concerning defense policy in the past. [F50-F58] ecision is produced by an algorithm which has as its ial component a Pearson product moment correlation cient. [G1-G22] The TFC levels of the alliance leader

aid requester are correlated over time and the resulting ficient is modified such that an r of -1.0 indicates an ance fidelity value (AF) of 0 and a correlation of +1.0 uces an alliance fidelity value of 1.0.

Finally, consideration is given to the need of the aid-esting nation as embodied in its request relative to r nations' requests. The total value of aid that nation ll receive from nation I, TAID(J), is

$$\text{(J)} = \frac{\dfrac{\text{AIDREQ(J)}}{\sum_{L=\text{allies}} \text{AIDREQ(L)}} + \text{TF(J)} + \text{AF(J)}}{3} * \text{SURPLUS(I)} \qquad (40)$$

e AIDREQ(J) is the total aid requested from the leader ation J. This total aid is then divided up among the ous commodities in relation to the degree that each odity was originally requested by a nation. [F59-F138]

The sequence of allocation decisions is completed with apportionment of any resources remaining uncommited into us sectors in proportion to the size of existing sector tments. [F172-F183]

Provision is made for nations to express hostility d one another during each time period. [F172-F183] This matic or verbal conflict behavior is generated by a set uations relating the level of conflict, HOST, to several rs.

The first component in the determination of hostility s is a reactive factor. The action-reaction phenomena

s been frequently discussed, and the work of Zinnes is
rticularly relevant here.[49] Zonnes examined both histori-
l and simulate data and found a positive relationship
tween "x's expression of hostility to y and y's perception
unfriendliness," and that "there is a positive relation-
p between the perception of unfriendliness and the
ression of hostility."[50] This would lead us to believe
t

$$HOST(I,J,T+1) = REACT * HOST(J,I,T) \qquad (41)$$

a reasonable formulation. However, we will add to this
ic formulation the proposal that nations react to expected
tility by anticipating how hostile another nation will be
he future with the aim of deterring that behavior.
rdingly, the basic information processing rules discussed
ier are used to yield a value for HOST(J,I,T+1), and the
tion becomes

$$HOST(I,J,T+1) = REACT * HOST(J,I,T+1) \qquad (42)$$

HOST(J,I,T+1) is an estimated value. The reader will
l that when Information Processing Rule 4 is used the
quations given above are identical.

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[49]Dina Zinnes, "A Comparison of Hostile Behavior of
ion-Makers in Simulate and Historical Data," <u>World
ics</u>, XVIII, 3 (April, 1966), pp. 474-502.

[50]<u>Ibid</u>., p. 477.

There are factors which work to repress the expression
hostility. We have included three kinds of buffers which
dify the expression of hostile feelings. In some cases
ese buffers serve to store hostility indefinitely, and in
her cases they serve as a means of displacing hostility
om one nation to another.

The first of these buffers is that which comes into
y when there are great power differences between actor
target. Rummel reports a significant positive associa-
n between the discrepancy in military power between a
r of nations and the level of threats, accusations, and
tests that pass between the nations.[51] Brody, Benham,
Milstein found that if a weaker simulated nation
ceived hostility emanating from a stronger one, it was
likely to respond with verbal hostility than if it
ated from a weaker one.[52] This finding has been
ially supported in analyses using real world data, as
. Erich Weede reports, "powerful states are more likely
ngage in verbal conflict activities than relatively
rless states."[53]

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[51]Rudolf J. Rummel, "A Social Field Theory of Foreign
lict Behavior," Peace Research Society (International)
rs, IV (1965), p. 143.

[52]Richard A. Brody, Alexandra H. Benham, and Jeffrey
Milstein, "Hostile International Communications, Arms
ction, and Perception of Threat: A Simulation Study"
ford, Cal.: Institute of Political Studies, Stanford
rsity, July, 1966).

[53]Erich Weede, "Conflict Behavior of Nation-States."
delivered at the Midwest meeting of the Peace Research
ty (International) on April 17, 1969, p. 1.

The power buffer term we offer is;

$$PBUFF * \frac{TFC(I,T+1) - TFC(J,T+1)}{TFC(I,T+1) + TFC(J,T+1)}$$

en nation I's expected military strength, TFC(I,T+1), is ro, nation I will suppress the expression of the amount hostility indicated by PBUFF.

The second buffer operating in the hostility expression ation may be considered an alliance tolerance factor. The eral formulation of this factor is such that a nation will ore and/or not react to an ally's hostile behavior if it s not exceed a certain threshold value, ABUFF. Zinnes nd that there was a tendency for a nation to perceive less tility from an ally than a non-ally and to express less tility to an ally than a non-ally.[54] Consequently we ude a term

$$ABUFF * ALLY(I,J) \qquad (44)$$

e ALLY is 1 when I and J are allies and 0 otherwise. e are two reasons why we feel the inclusion of this term ecessary. First, it would seem that allies should be ready to perceive hostility from one another and less tive to any hostility that is perceived. Secondly, aining the unity of the alliance requires a certain t of "turning the other cheek," and the parameter ABUFF ates how much hostility will be ignored.

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[54] Zinnes, <u>op</u>. <u>cit</u>., pp. 484-486.

The third buffer factor and final component in the stility equation concerns the effect of close economic es. The reasons for including this term are similar to ose given above for the alliance buffer factor. The ronger the economic dependence, the more effort will be de to repress the expression of hostility, up to a thres- .d value, for the sake of maintaining economic ties. relevant formulation is

$$EBUFF * \frac{TRADE(J,I,T)}{\sum_{K=1}^{N} TRADE(K,I,T)} \tag{45}$$

re TRADE(i,j,k) is the flow of goods from nation i to ion j in period k, and the parameter EBUFF indicates the unt of hostility that would be ignored if all of nation imports came from nation J.

The complete hostility equation for nation I with rence to nation J at time T is

$$\begin{aligned} HOST(I,J,T+1) = {} & REACT * HOST(J,I,T+1) \\ & - PBUFF * \frac{TFC(I,T+1) - TFC(J,T+1)}{TFC(I,T+1) + TFC(J,T+1)} \\ & - ABUFF * ALLY(I,J) \\ & - EBUFF * \frac{TRADE(J,I,T)}{\sum_{K=1}^{N} TRADE(K,I,T)} \end{aligned} \tag{46}$$

This completes the description of the essential
cision processes that a simulated nation goes through in
e period of simulated time. Before the next sequence of
cision processes is initiated, the relationships discussed
Section 1 and 2 are called upon to calculate the conse-
nces of the decisions that have been made and define the
uational context for the next round of decision-making.

Our description has not included the more technical
ects of the computer model. We have chosen rather to
us on its theoretical aspects. Those who are interested
for example, the various input and output options that
model allows are directed to the appendix. We do not
n to imply that such matters are trivial, for as anyone
has worked with computer models knows, they often seem
demand a disproportionate amount of time.

The formulations given in this chapter constitute what
onsider to be the best that could be assembled given the
traints of time, money and competence. As the resources
nd, so will the model.

CHAPTER III

THE EXPERIMENTAL INPUTS

The results reported in the next two chapters are ed on twenty-four runs of the simulation model, each run ng ten periods in duration. This chapter is devoted to licating the values that were used as variables and ameters to generate these data. Sections 1 and 2 discuss variable and parameter settings which the scheduled nty-four system had in common. Sections 3 and 4 discuss variables and parameters that were varied within the schedule.

Variable Initialization: Cross-System Constant

The recursive nature of the model demands values for basic variables which have been borrowed from the r-Nation Simulation model. These variables are: total c capability (TBC), total force capability (TFC), valida- satisfaction overall (VSm), probability of office- ing (POH), decision latitude (DL), and probability of lution (PR). This set of variables determines the pre- sional state of each national system, and it is the e of these variables at time T=1 that we are concerned here. Each of the twenty-four systems is composed of nations, and the values given in Table 1 for these five

tions were the same for all twenty-four systems.

TABLE 1

COMMON INITIAL VALUES FOR

BASIC VARIABLES IN PERIOD 1

	NATION				
RIABLE	1	2	3	4	5
TBC	7500.	17000.	9000.	34000.	37000.
TFC	100.	1000.	800.	2850.	2713.
VSm	4.	4.	5.	6.5	6.
POH	.8	.6	.7	.7	.9
DL	6.	4.	3.	5.	7.
PR	0	0	0	0	0

These starting values are based on ones used in the SAFE II Inter-Nation Simulation runs conducted by John er and Wayman Crow.[1] The TFC variable is a weighted sum their conventional and nuclear capability categories. shall have occasion to refer often to these series of runs in the setting of variables and parameters.

The WINSAFE II INS runs were designed to explore the ifications of the capacity to delay response, that is, "invulnerability and deliverability of a retaliatory e after accepting the most devastating blow or series lows the initiator of a nuclear attack can deliver."[2]

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[1]John R. Raser and Wayman J. Crow, WINSAFE II: An r-Nation Simulation Study of Deterrence Postures Embody- Capacity to Delay Response (La Jolla, Cal.: Western vioral Sciences Institute, July, 1964).

[2]Ibid., p. I-1.

xperimental intervention involved giving to nations for periods of time the capacity to delay response. The es in national behavior were then noted and conclusions about the effects of this capacity.

This set of INS runs will be compared to the SIPER in the following two chapters, and we must keep in mind the behavior of the INS model is in part due to these al experimental conditions as well as to the basic e of the model. However, this set of data is the best is available at this time. The intervention effects r to be less pronounced than in the Brody-Driver INS for example.[3]

Two other variables that require initialization, but nique to the SIPER model, are the aspiration levels olitical stability and economic growth. All five nations with the same aspiration levels, and again, all twenty-systems begin with the same national aspiration levels.

The aspiration level for political stability (ALPOH) ssigned an initial value of .8 for all nations. An ction of the cabinet meeting minutes from the WINSAFE II suggested that subjects seemed to desire a POH value of .8 on a scale of 0 to 1.0. Accordingly, this value was in this series of computer runs.

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[3]The Brody-Driver runs, known as INS-8, are described chard A. Brody, "Some systemic Effects of the Spread of ar Weapons Technology: A Study Through Simulation of tinuclear Future," Journal of Conflict Resolution, VII, cember, 1963), pp. 663-753.

The initial value for the aspiration level for economic owth (ALGRO) was similarly determined. The value used was ve per cent growth per period. The use of this as the itial value for ALGRO seems reasonable both in terms of at the participants in the WINSAFE II runs appear to have nted and what economists today consider a "good" growth te for a national economy.[4]

Assigning an initial value to the aspiration level for .tional security (ALSEC) is not necessary since the equa- .ons pertaining to ALSEC are not recursive with respect to .SEC. The value of ALSEC in any period is not directly ependent on any previous value of ALSEC, as was the case ith ALPOH and ALGRO.

The alliance and influence structure variables require nitialization as well. All systems were initially set up ith the following bipolar configuration.

ALLIES

NATION	1	2	3	4	5
1	1	0	1	0	1
2	0	1	0	1	0
3	1	0	1	0	1
*4	0	1	0	1	0
*5	1	0	1	0	1

\ 1 indicates that the row nation and column nation are

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[4]Jagdish Bhagwati, The Economics of Underdeveloped Countries (New York: World University Library, 1966).

llied, and the asterisks identify the two leaders of the
pposing alliances.

Parameter Settings: Cross-System Constant

As we noted earlier, each simulated national system s a generation rate or productivity coefficient associated th each of its economic sectors. The same set of national neration rates, listed below, was used for all twenty-four mulated international systems.

	GENERATION RATE		
NATION	CSGR	BCGR	FCGR
1	1.2	1.0	1.5
2	1.0	1.2	0.7
3	1.1	1.0	0.7
4	1.4	1.3	2.0
5	1.4	1.2	2.1

ese rates are based on those used in the WINSAFE II simula- on runs. They are generally in conformity with those used other INS runs.

The SIPER model requires the setting of five types of rameters: information processing, goal determination, goal erationalization, international exchange, and international stility. The information processing parameters were varied ross systems and will be discussed in section 4.

al Determination Parameters

The goal determination parameters were introduced in ree previously discussed equations:

$$ALPOH(I,T) = ALPI * ALPOH(I,T-1) + ALPA * [POH(I,T) - ALPOH(I,T-1)] + ALPE * [POH(K,T) - POH(I,T)] \quad (17)$$

$$ALGRO(I,T) = ALGI * ALGRO(I,T-1) + ALGA * [PDTAC(I,T) - ALGRO(I,T-1)] + ALGE * [PDTBC(K,T) - PDTBC(I,T)] \quad (19)$$

$$AD = \sum_{\text{non-allies}} ALSID * HOST(J,I,T+1) * TFC(J,T+1) \quad (22)$$

The parameters for the first and second of the above equations are essentially the same, and we can discuss them concurrently.

The ALPI and ALGI parameters are measures of the inertia of goals. These parameters indicate how the aspiration levels change when there is no pressure for goal change being exerted. This would be the case when POH(I,T) = ALPOH(I,T-1) and POH(K,T) = POH(I,T) in the first equation. One might postulate that in the absence of stimulation, either through success or failure, goals tend to rise or fall, but here we have assumed that in the absence of such stimulation goals remain constant. Hence, the parameters ALPI and ALGI were assigned values of 1.0.

ALPA and ALGA are parameters that govern the rate of adaptation or the speed at which any gap between POH and ALPOH is closed. The determination of reasonable values for these two parameters is not a simple matter, and we have sought only tentative values. Since the variables ALPOH and ALGRO are conceptual constructs, there is little hope at this time of deriving rigorous measures of the dependent and independent variables and determining parameter values by the use of standard estimation techniques. In view of this, we have relied on a less rigorous estimation procedure for the parameters ALPA, ALGA, ALPE, and ALGE.

We assumed at the outset that one's own experience is twice as salient as the experience of others. Hence, 2*ALPE = ALPA and 2*ALGE = ALGA. Returning to the cabinet meeting minutes of the WINSAFE II runs, we sought to estimate the rates of change of goals among the participants. Through a series of trial and error curve fittings, the parameters ALPA and ALGA were finally assigned a value of 0.1 and ALPE and ALGE a value of 0.05. Although these methods seem primitive, the alternative of assigning these parameters zero values and thus prohibiting any change in goals seemed less attractive.

The ALSID parameter was set at 0.5 for the following reason. An inspection of the WINSAFE II cabinet meeting minutes suggested that nations become alarmed about the hostile intentions of another nation when they receive two

or more hostile messages from it in one period of time. Statements of hostile intention are discounted by one-half when national security matters are under consideration.

Goal Operationalization Parameters

The goal operationalization parameters were introduced in the following equations.

$$CSP(I,T) = CSP(I,T-1) + ALPOR * [ALPOH(I,T) - POH(I,T)] * CSP(I,T-1) + ECAF * PR(I,T) \quad (28)$$

$$BCP(I,T) = BCP(I,T-1) + ALGOR * [ALGRO(I,T) - POTBC(I,T)] * BCP(I,T-1) \quad (29)$$

ALPOR, the aspiration level for POH operationalization rate, is a scale parameter indicating the proportional increment in CS production that is necessary to achieve the desired POH level. We can determine a range of effective values for ALPOR with knowledge of the relationship that the level of CS production has to the determination of POH, but not a specific value due to other factors which determine POH. From this range of acceptable values the figure 0.25 was selected.

This figure indicates that under the worst of all possible conditions, that is, ALPOH equal to one and POH equal to zero, the maximum increase in CSP would be 25 per cent. An inspection of referent consumption data suggested that this figure is a reasonable estimate of the upper limit of a nation's ability to shift resources from one

sector to another. The emergency CS allocation factor, ECAF, was assigned the value of 0.05, indicating that when revolution is a virtual certainty, CSP would be increased by 0.05. The aspiration level for growth operationalization rate, ALGOR, was set equal to 0.2 by reasoning similar to that used to set the ALPOR parameter.

International Exchange Parameters

The international exchange parameters are used in the following equations.

$$TOTIM = ITAF * TBC(I,T) \qquad (32)$$

$$EXPRC(J,I,K,L) = EXPRC(I,J,K,L) - APPF * [2 * ALLY(I,J)-1] \qquad (35)$$

$$* \; EXPRC(I,J,K,L) + ESPF * \frac{TBC(J,T)}{TBC(J,T) + TBC(I,T)} - .5 \qquad (36)$$

$$* \; EXPRC(I,J,K,L) + \frac{JRPF * HOST(I,J,T)}{\sum_{K=1}^{N} HOST(J,K,T)}$$

$$* \; \mathrm{Log}_{10} \sum_{K=1}^{N} HOST(I,K,T) + 1$$

$$* \; EXPRC(I,J,K,L) \qquad (37)$$

The international trade autarky factor, ITAF, was assigned the value of 0.10. Referent data suggests that on the average a nation's imports represent about twenty per cent

of the value of its gross national product,[5] while the appropriate level for INS nations is a good deal lower. The figure used was selected as a compromise between the two data sources.

The APPF parameter, the alliance preference pricing factor, and the ESPF parameter, the economic strength pricing factor were varied across the twenty-four runs, and they will, therefore, be discussed specifically in section 4. The international risk pricing factor, IRPF, was assigned a value of zero for this set of runs for the reason that it was considered desirable at this stage to keep the loop between dyadic conflict, in the form of diplomatic conflict, and dyadic cooperation, in the form of trade, open. In the future, when we close this loop, we can fully understand the results of linking these phenomena.

International Hostility Parameters

The equation given below contains the parameters relevant to the transmission of hostility.

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[5] Table 46, "Foreign Trade (Exports and Imports) as a Percentage of G.N.P." in Bruce M. Russett, et al., World Handbook of Political and Social Indicators (New Haven: Yale University Press, 1964, pp. 162-165, indicates that the mean trade level for 81 nations is 38 per cent.

$$HOST(I,J,T+1) = REACT * HOST(J,I,T+1) - PBUFF * \frac{TFC(I,T+1) - TFC(J,T+1)}{TFC(I,T+1) + TFC(J,T+1)} - ABUFF * ALLY(I,J) - EBUFF * \frac{TRADE(J,I,T)}{\sum_{K=1}^{N} TRADE(K,I,T)} \quad (46)$$

The response parameter REACT was assigned a value of 1.0 indicating neither a systematic propensity to escalate tensions by over-reaction nor to deescalate them by under-reaction, but rather to respond directly to the expected level of hostility. The power buffer parameter, PBUFF, was tentatively given the value 0.25 when an extrapolation of INS data suggested such a value as reasonable. ABUFF, the alliance buffer, was set at 1.0 indicating that a nation would ignore 1 unit of hostility if the nation of its origin was an ally. Finally, the economic buffer, EBUFF, was given a value of zero for the same reason that we assigned the international risk pricing factor, IRPF, a zero value.

3. Variable Initialization: Cross-System Variants

There are several other variables that require initial values in addition to those discussed in section 1. They are: the proportion of resources allocated to consumption (CSP), investment (BCP), and defense (FCP), as well as the proportion of total force capability assigned the role of internal security (FICP). The dyadic trade, aid and hostility variables also require initial values. We must also specify

what changes we wish to make in the alliance structure outlined in section 1.

These variables constitute the set of decisions taken by the various nations in time period 1. The second period values of the variables total basic capability (TBC), total force capability (TFC), overall validator satisfaction (VSm), probability of office-holding (POH), decision latitude (DL), and probability of revolution (PR), are the consequence of these decisions, and they constitute the predecisional setting when the computer model is activated.

Six different sets of initial values were used in the twenty-four runs. Tables 2 through 7 indicate the values in each set. These values are the results of the first decision-making period of six of the WINSAFE II runs. Since there was no trade or aid during the first period of any of these runs, the variables TRADE and AID were assigned zero values.

Table 2 indicates, for example, that in variable set I nation 1 allocated its resources in the following way: 94.87 per cent went to consumption, 5.00 per cent went to investment, and 0.13 per cent went to defense. Thirty per cent of its total force capability was devoted to internal security, and no hostile messages were transmitted.

Table 2 also indicates what the consequences of the decisions taken in period one were for variable set I. These values set the stage for action by the computer model.

Table 8 indicates the scheduled alliance changes for each of the six variable sets. These alliance changes mirror the changes that occurred in the six WINSAFE II INS runs that serve as our data base.

The variable sets I through VI create systems moving in different directions from a common origin. In Chapter V we will consider the effects of setting the computer model down these diverse paths.

4. Parameter Settings: Cross-System Variants

In this series of computer runs we have decided to vary two types of parameters. The first type regulates the manner in which expectations of future behavior are developed by a nation, and the second type governs the degree to which non-economic factors are introduced into international trade.

In section 3 of Chapter II we discussed the various optional information processing rules that we could specify. Two of those rules have been selected for systematic consideration. Twelve simulated systems were generated using the null rule, Rule 4. This rule states that future behavior will be the same as present behavior. Rule 0, the pragmatic rule, was used in the remaining twelve computer runs. This rule specifies how an information processing rule is selected, rather than how information is to be processed. That is, the choice of Rule 0 activates a process by which each of the four basic rules are in turn used to estimate the present level of behavior utilizing information from periods past.

TABLE 2

VARIABLE SET I

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9487	.9588	.9300	.8824	.8919
	BCP	.0500	.0294	.0589	.1029	.0811
	FCP	.0013	.0118	.0111	.0147	.0270
	FICP	.2000	.2000	.1500	.0437	.1000
	HOST(I,1)	0	0	0	0	0
	HOST(I,2)	0	0	0	0	0
	HOST(I,3)	0	0	0	0	0
	HOST(I,4)	0	1	0	0	1
	HOST(I,5)	0	0	0	0	0
CONSEQUENCES	TBC	7725.	13128.	9350.	33270.	35168.
	TFC	105.	790.	810.	2865.	4057.
	VSm	5.5	3.0	3.5	4.	6.
	POH	.8	.6	.5	.7	.9
	DL	6.	5.	3.	5.	7.
	PR	0	.4	.4	.6	0

TABLE 3

VARIABLE SET II

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9333	.9500	.9053	.8529	.9162
	BCP	.0400	.0329	.0778	.0824	.0865
	FCP	.0267	.0171	.0189	.0647	.0297
	FICP	.1500	.0000	.3010	.2000	.2000
	HOST(I,1)	0	1	0	1	1
	HOST(I,2)	0	0	0	2	0
	HOST(I,3)	0	1	0	0	0
	HOST(I,4)	7	3	0	0	0
	HOST(I,5)	3	1	2	0	0
CONSEQUENCES	TBC	7050.	17332.	9320.	32360.	35700.
	TFC	390.	1103.	873.	6340.	3240.
	VSm	4.	5.5	2.	5.	5.
	POH	.8	.7	.4	.8	.9
	DL	6.	4.	3.	5.	7.
	PR	.55	0	.55	0	0

TABLE 4

VARIABLE SET III

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9667	.9559	.9222	.8529	.8919
	BCP	0	.0353	.0556	.0794	.0676
	FCP	.0333	.0088	.0222	.0676	.0405
	FICP	.150	.20	0	1.0	.100
	HOST(I,1)	0	0	0	0	0
	HOST(I,2)	0	0	1	0	0
	HOST(I,3)	0	1	0	0	1
	HOST(I,4)	2	2	1	0	1
	HOST(I,5)	0	0	0	0	0
CONSEQUENCES	TBC	7350.	16530.	9120.	32620.	37060.
	TFC	465.	850.	900.	6130.	5340.
	VSm	5.5	5.0	3.0	4.5	5.5
	POH	.8	.7	.5	.7	.9
	DL	6.0	5.0	3.0	5.0	7.0
	PR	0	0	.65	0	0

TABLE 5

VARIABLE SET IV

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9000	.9559	.9444	.8824	.9189
	BCP	.1000	.0441	.0556	.0588	.0622
	FCP	.0000	.0000	.0000	.0588	.0189
	FICP	.10	.30	.10	.10	.10
	HOST(I,1)	0	1	0	1	0
	HOST(I,2)	0	0	1	0	0
	HOST(I,3)	0	0	0	2	1
	HOST(I,4)	0	1	0	0	3
	HOST(I,5)	0	0	0	2	0
CONSEQUENCES	TBC	6800.	17560.	9320.	33620.	34620.
	TFC	90.	900.	720.	6190.	3660.
	VSm	3.	5.	3.5	5.	6.
	POH	.7	.7	.5	.8	.9
	DL	6.0	4.0	3.0	5.0	7.0
	PR	.65	0	.65	0	0

TABLE 6

VARIABLE SET V

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9333	.9118	.9500	.9000	.8541
	BCP	.0667	.0706	.0500	.0588	.0689
	FCP	0	.0176	0	.0412	.0770
	FICP	.02	.10	.10	.10	.10
	HOST(I,1)	0	0	0	0	0
	HOST(I,2)	0	0	0	0	1
	HOST(I,3)	0	0	0	1	0
	HOST(I,4)	1	2	0	0	1
	HOST(I,5)	1	2	4	0	0
CONSEQUENCES	TBC	7850.	17800.	9100.	33620.	39320.
	TFC	90.	1110.	720.	5115.	7784.
	VSm	6.5	2.0	6.0	4.0	6.5
	POH	.9	.5	.7	.7	.9
	DL	6.0	4.0	3.0	5.0	7.0
	PR	0	.55	0	.65	0

TABLE 7

VARIABLE SET VI

		NATION				
	VARIABLE	1	2	3	4	5
DECISIONS	CSP	.9200	.9118	.9111	.8824	.9027
	BCP	.0267	.0529	.0889	.0735	.0595
	FCP	.0533	.0353	0	.0441	.0378
	FICP	.10	0	0	.0441	.0378
	HOST(I,1)	0	0	0	0	0
	HOST(I,2)	4	0	0	0	0
	HOST(I,3)	0	0	0	1	0
	HOST(I,4)	2	2	3	0	0
	HOST(I,5)	0	0	4	2	0
CONSEQUENCES	TBC	7150.	12984.	7970.	25576.	36660.
	TFC	690.	1270.	680.	5235.	5013.
	VSm	4.5	2.0	2.0	2.5	7.0
	POH	.8	.6	.4	.6	.9
	DL	6.0	5.0	4.0	5.0	7.0
	PR	0	.7	.65	.7	0

TABLE 8

ALLIANCE CHANGE SCHEDULE

VARIABLE SET	PERIOD	NATION	FORMER ALLIES	NEW ALLIES
I	7	3	1,5	2,4
II	4	3	1,5	2,4
II	7	1	5	2,3,4
III	4	2	4	1,3,5
III	6	3	1,2,5	4
IV	3	3	1,5	2,4
IV	6	1 2	5 3,4	3,4 5
VI	5	1,3	5	2.4

The most accurate of the four rules is then used to render a prediction concerning future behavior.

In section 5 of Chapter II we discussed the way in which noneconomic factors may influence the prices at which nations are willing to sell goods to one another. Two of those factors, the alliance preference pricing factor (APPF) and the economic strength pricing factor (ESPF), were varied in this set of computer runs. Twelve runs were made with pricing parameters set equal to zero. Trade in these systems is based strictly on comparative advantage; i.e., the relative differences between national generation rates. A departure from pure comparative advantage was introduced in the other twelve simulation runs. The alliance preference and economic strength pricing factors were set equal to 0.20 and 1.0 respectively. The first of these settings indicates that allies will be charged twenty per cent less for goods and non-allies will be charged twenty per cent more. The second indicates that larger nations will be asked to pay more for goods by smaller nations and the converse. For this specific parameter setting the price increase or decrease is proportional to the relative sizes of the nations' resource bases. That is, the proportional change in the prices that nation I is willing to sell goods to nation J is

$$\frac{TBC(I,T)}{TBC(J,T) + TBC(I,T)} - .5 \qquad (47)$$

Generally we will refer to the pure comparative advantage

pricing as unbiased pricing, and the departure from comparative advantage will be referred to as biased pricing.

5. The Experimental Design

The changes in variable initializations and parameter settings made in this schedule of computer runs were arranged in a factorial design. The model was run with each of the six variable settings in conjunction with each of the parameter combinations. Table 9 indicates the character of each of the twenty-four systems generated. We will consider the effects of these variations specifically in Chapter V.

TABLE 9

THE COMPUTER RUN SCHEDULE

INFORMATION RULE	EXPORT PRICING	VARIABLE SET	SYSTEM
Pragmatic	Unbiased	I	1
Pragmatic	Unbiased	II	2
Pragmatic	Unbiased	III	3
Pragmatic	Unbiased	IV	4
Pragmatic	Unbiased	V	5
Pragmatic	Unbiased	VI	6
Null	Unbiased	I	7
Null	Unbiased	II	8
Null	Unbiased	III	9
Null	Unbiased	IV	10
Null	Unbiased	V	11
Null	Unbiased	VI	12
Pragmatic	Biased	I	13
Pragmatic	Biased	II	14
Pragmatic	Biased	III	15
Pragmatic	Biased	IV	16
Pragmatic	Biased	V	17
Pragmatic	Biased	VI	18
Null	Biased	I	19
Null	Biased	II	20
Null	Biased	III	21
Null	Biased	IV	22
Null	Biased	V	23
Null	Biased	VI	24

CHAPTER IV

SIMULATED NATIONAL SYSTEMS

It has been noted that "...the problem of verifying simulation models remains today perhaps the most elusive of all the unresolved problems associated with computer simulation techniques."[1] Given this state of affairs we must nevertheless attempt an evaluation in order to estimate the model's validity and diagnose errors to be rectified in the future.

Generally it has been concluded that validating simulations is a special case of the general problem of verifying models of all sorts. However, simulations like SIPER and INS pose special problems when "whole sets of variables in the complex of national and international life are represented by simplified, generic factors, supposedly the prototypes of more elaborate realities."[2] Hence, as Hermann concludes, "comparisons of the simulation's variables and parameters with their assumed counterparts in the observable universe... can be particularly troublesome when the definitions must

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[1]Thomas H. Naylor _et al_., _Computer Simulation Techniques_ (New York: Wiley and Sons, 1966), p. 310.

[2]Harold Guetzkow, "Structured Programs and Their Relation to Free Activity within the Inter-Nation Simulation," in Harold Guetzkow _et al_., _Simulation in International Relations_ (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963), p. 105.

correspond to a simulation variable or parameter that is either an analogue or a prototype intended to combine numerous features of the reference system."[3]

Computer models like SIPER, on the other hand, have the advantage of perfect internal validity.[4] That is, given than no "errors of functioning" occur, as Thuring calls them,[5] any simulation run can be perfectly replicated given the same input, including, of course, the same string of pseudo-random numbers if the model has stochastic processes.

It is more difficult to assess the "face validity" of complex computer models than it is for other more visible types of games and models. We can make evaluations of the apparent realism of specific components or processes in the model, but such assessments of the overall model are without foundation when so much that is going on is invisible to the observer. Observing the computer while the simulation is being run does not enable the researcher to get the feeling of realism or unrealism that one gets when one observes an Inter-Nation Simulation world in action.

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[3]Charles Hermann, "Validation Problems in Games and Simulations with Special Reference to Models of International Politics," Behavioral Science, XII (May, 1967), p. 222.

[4]For a further discussion of types of validity see Hermann, op. cit., pp. 220-224, and Charles F. Hermann and Margaret G. Hermann, Validation Studies of the Inter-Nation Simulation (China Lake, Calif., U.S. Naval Ordinance Test Station, December, 1963), pp. 26-34.

[5]A. M. Turing, "Computing Machinery and Intelligence," Computers and Thought, ed. Edward A. Feigenbaum and Julian Feldman (New York: McGraw-Hill, 1963), pp. 11-35.

Another type of validation that has been proposed is "event validity." The question becomes whether simulation produces the same discrete actions or occurrences that are observed in the referent system. Charles Hermann's simulation of the outbreak of World War I is clearly a case for which "event validity" is an appropriate validation criterion.[6] However, it does not seem appropriate here, as the desire is to reproduce patterns of behavior rather than to replicate particular actions or occurrences.

We are not, however, without some guidance in this question of validation. Guetzkow has commented,

> ...by using some systematic rigor in making comparisons between simulations and realities, by taking reference data largely from extant international systems rather than from laboratory or field research about noninternational phenomena, and by finding in simulations internal processes and outputs which correspond to reference processes as well as reference outcomes, a convergence of evidence is gained which increases the credibility of the theoretical construction of simulations.[7]

It is worthwhile to consider the statement made by Guetzkow concerning the nature of the referent data. The SIPER model may be compared either to its parent, the Inter-Nation Simulation, or their common referent, the "real" world. The predominant strategy that will be followed here, however,

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[6] Charles F. Hermann and Margaret G. Hermann, "An Attempt to Simulate the Outbreak of World War I," American Political Science Review, LXI (June, 1967), pp. 400-416.

[7] Harold Guetzkow, "Some Correspondences Between Simulations and 'Realities' in International Relations," New Approaches to International Relations, ed. Morton A. Kaplan (New York: St. Martin's Press, 1968), p. 208.

will be to compare both SIPER and INS to the real world to see if the offspring is an improvement on its ancestor.

Guetzkow's distinction between process and outcome seems to deserve further examination, as well. From the viewpoint of the international system, the processes that determine the behavior and structure of that system are the patterns of behavior exhibited by the nations that make up the system. The outputs, on the other hand, of these processes are the descriptions of the state of an international system at a point in time. In other words, national behavior processes produce outputs which in turn define the status of the international system.

Our focus will be at two levels, the national system and the international system.[8] First we shall want to ask the question, do simulated nations behave like real world nations? This chapter is an attempt to answer that question. Secondly we want to know if the simulated international systems are like the observed international system. This question is addressed in the next chapter.

1. The Behavior of National Systems

Since we are generating behavior for prototypic rather than isomorphic nations, our methods for comparing the

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[8]For a further elaboration of the advantages and disadvantages of each of these levels of analysis see J. David Singer, "The Level-of-Analysis Problem in International Relations," The International System: Theoretical Essays, ed. Klaus Knorr and Sidney Verba (Princeton: Princeton University Press, 1961), pp. 77-92.

behavior of national systems in the simulated and referent worlds must be adjusted. If we ask whether any simulated nations behave like the United States, we are not likely to progress very far in reaching a conclusion about the validity of the model. If, on the other hand, we ask whether large simulate nations act like large referent nations, like the United States, we are likely to achieve better insight.

If, for example, we were to find that larger nations engage in more diplomatic conflict than smaller nations in the real world, then we would want to find a similar relationship in the simulate data before we would grant the model some validity. Similarly, if we find no relationship in the real world between the size of a nation and the amount of diplomatic conflict it engages in, then in order for the model to receive a passing grade we would not want to see the relationship in the simulate data.

We shall, therefore, test a series of hypotheses about the relationships between attributes and behavior of real and simulated nations. The attributes we have chosen have been isolated both theoretically[9] and empirically[10] as variables of special importance. These are size, development, and accountability.

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[9]James N. Rosenau, "Pre-Theories and Theories of Foreign Policy," Approaches to Comparative and International Politics, ed. R. Barry Farrell (Evanston: Northwestern University Press, 1966), pp. 27-92.

[10]Jack Sawyer, "Dimensions of Nations: Size, Wealth, and Politics," American Journal of Sociology, LXXIII (September, 1967), pp. 145-172.

Size is a measure of magnitude. We commonly mean the bulk or mass of an entity when we refer to its size, but with reference to national systems there is also the connotation of resource potential. Several of the measures which have been isolated in factor analyses of real world data seem to have the common element of resource potential.[11] We will use as our measure of size in the real world data national population, which has the advantage of being a rather complete and reliable statistical series.[12] In the SIPER and INS data we will use total basic capability as our size measure, which seems to correspond conceptually with population more than any other simulation variable we have. Certainly in both the referent and simulate worlds we are measuring the resource potential of nations with these variables.

Measuring development commonly means some assessment of the efficiency of a national economy. When we call a nation developed we are asserting that its economic input-output ratio is relatively lower than other nations, which are considered undeveloped. As our aggregate measure of the

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[11]Rudolf J. Rummel, "Indicators of Cross-National and International Patterns," American Political Science Review, LXIII (March, 1969), pp. 127-147.

[12]Population data is taken from Bruce Russett, et al., World Handbook of Political and Social Indicators (New Haven: Yale University Press, 1964), pp. 15-21. The choice of this indicator for the size variable is supported by Rummel, op. cit., p. 134. The indicator is $\log_{10}$ transformed to reduce the skewness of the distribution.

productivity (output/input) of real national economies we will use per capita gross national product. With all its shortcomings, this measure is still considered the best single indicator of development.[13] We will use an analogous measure for the simulated nations. Let us set the variable gross simulated product equal to the sum of consumers' goods, investment goods, and security goods produced. If we divide this by total basic capability, we will have an aggregate measure of the productivity of the simulated nation's economy.[14]

The third attribute variable we have chosen, accountability, is more difficult to define than the previous two. It is unlikely that the differences between the political systems of real nations may be reduced to one dimension without losing a good deal of information about those systems. But it would be folly to try to deal with the full variety of political systems at this stage of our work. Fortunately, we are not without some guidelines in examining national

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[13]For a discussion of the advantages and disadvantages of this indicator see Irma Adelman and Cynthia Taft Morris, Society, Politics, and Economic Development (Baltimore: John Hopkins Press, 1967), pp. 84-90.

[14]It should be evident that development is a weighted average of the national generation rates.

$$\text{Development} = a_1 * \text{CS generation rate} + a_2 * \text{BC generation rate} + a_3 * \text{FC generation rate}$$

where the weights a_1, a_2, a_3 are equal to the proportion of the total basic capability of the nation which is allocated to the production of consumer goods (CS), investment goods (BC), and security goods (FC) respectively in a given period.

political systems, and the work of Gregg and Banks is particularly noteworthy.[15] The first factor which they extracted in their factor analysis of the cross-polity survey data was named access.[16] It would seem that Gregg and Banks have captured the same phenomenon that Rosenau speaks of as accountability, but the nominal perspectives are different. If a citizen has access to the political system, then similarly the political leader is accountable to the citizen. We shall take our measure from another study of the cross-polity survey data in which a factor analysis of the nations in the survey was performed.[17] An inspection of the rotated factor matrix indicates that the nations that load heavily on the first factor are precisely those nations that we would describe as having open, accessible, or accountable political systems. We have therefore decided to use a nation's loading on this first factor as a measure of the accountability. The

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[15]Phillip M. Gregg and Arthur S. Banks, "Dimensions of Political Systems: Factor Analysis of a Cross-Polity Survey," American Political Science Review, LIX (June, 1965), pp. 602-614.

[16]The variables which loaded positively on this factor were: electoral system, constitutional regime, group opposition, status of legislature, horizontal power distribution, representativeness of regime, press freedom, aggregation by legislature, military neutral, conventional ideological orientation, articulation by parties, articulation by associational groups, and modern bureaucracy. Ibid., p. 608.

[17]Arthur S. Banks and Phillip M. Gregg, "Grouping Political Systems: Q-Factor Analysis of a Cross-Polity Survey," American Behavioral Scientist (November, 1965), pp. 3-6.

measure of accountability in the simulate worlds is ten minus the decision-latitude of the simulate nation. Obviously the higher the elite's decision-latitude, the less accountable they are to the citizenry. Hence, we want to take the difference between complete decision-latitude, ten, and the decision-latitude of the simulate nation as our measure of the accountability of its political system.

Let us now consider what behavioral phenomena we wish to relate these attributes to.

From the wide variety of behavior that we observe nations exhibiting we must, by necessity, select particular phenomena for study and neglect others. Our choices as to the exclusion or inclusion of a variable were guided by theoretical, empirical, and practical considerations. The variables chosen should have theoretical significance; that is, they should be essential to virtually any theoretical abstraction drawn from the relevant observable phenomena. Their theoretical import should be confirmed with empirical evidence. Lastly, the variables should be measurable.

Four areas of national behavior are examined: behavior pertaining to political stability, behavior pertaining to economic growth, behavior pertaining to national security, and behavior pertaining to international cooperation and conflict.

The political stability area contains five variables. The first three of these, turmoil, conspiracy, and internal

war, have been isolated theoretically and empirically by several authors.[18] We do not think we can improve on Gurr's definitions of these variables.

> Turmoil: relatively spontaneous, unstructured mass strife, including demonstrations, political strikes, riots, political clashes, and localized rebellions.
>
> Conspiracy: intensively organized, relatively small-scale terrorism, small-scale civil strife, including political assassinations, small-scale terrorism, small-scale guerrilla wars, coups, mutinies, and plots and purges, the last two on grounds that they are evidence of planned strife.
>
> Internal war: large-scale, organized, focused civil strife, almost always accompanied by extensive violence, including large-scale terrorism and guerrilla wars, civil wars, private wars, and large-scale revolts.[19]

Gurr's indicators of these variables for the referent nations are used in the analysis.

INS and SIPER do not produce any direct measure of turmoil behavior; however we can measure this behavior indirectly. Validation Satisfaction overall (VSm) is a general measure of the satisfaction of the citizenry with the political system, and if we transform this variable by

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[18] R. J. Rummel, "Dimensions of Conflict Behavior Within and Between Nations," General Systems Yearbook, VIII (1963), pp. 1-50; Raymond Tanter, "Dimensions of Conflict Behavior Within and Between Nations, 1957-1960," Journal of Conflict Resolution, X (March, 1966), pp. 41-64; Ted A. Gurr, " Causal Model of Civil Strife: A Comparative Analysis Using New Indices," American Political Science Review, LXII (December, 1968), pp. 1104-1124.

[19] Gurr, op. cit., p. 1107.

subtracting it from the level of perfect satisfaction, ten, we receive a measure of the citizenry's dissatisfaction. Although this measure is affective rather than behavioral, we will assume we are measuring potential turmoil. This approximation should be sufficient for our purposes. As to conspiracy and internal war, we find more directly analogous variables in the simulated worlds than with turmoil. We shall call a simulated nation's probability of revolution (PR) its conspiracy score and the costs of revolution (cR) it incurs in a particular period its internal war score for that period.

The fourth variable, stability, does not lend itself so easily to definition or measurement. The prevailing views in the literature seem to fall into two groups: those that see stability as the absence of destabilizing events[20] and those who see stability as to some degree independent of, although not necessarily orthogonal to, instability.[21] The former interpretation is followed here.

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[20]Feierabend and Feierabend computed political stability by counting events of aggressive behavior directed against the political system. See Ivo K. Feierabend and Rosalind L. Feierabend, "Aggressive Behavior Within Polities, 1948-1962: A Cross-National Study," Journal of Conflict Resolution, X (September, 1966), pp. 249-271. The emphasis in this point of view is on the degree to which the continued existence of the system is threatened by violence.

[21]Banks and Textor speak more in terms of major constitutional change when they discuss stability, and more emphasis is placed on whether major change has taken place in the political system, rather than the means by which this change was brought about. See Arthur S. Banks and Robert B. Textor, A Cross-Polity Survey (Cambridge, Mass.: M.I.T. Press, 1963).

The real world measure of stability is based on Gurr's Total Magnitude of Civil Strife index.[22] Since we want to measure stability rather than instability, the index has been transformed by multiplying each nation's value by -1. In the SIPER and INS data we have a variable which evidence gathered by Charles Elder and Robert Pendley indicates is analogous to stability of the system, the probability of continued office holding (POH).[23]

The fifth and last variable in the political stability area is consumption. It is included here because of the theoretical and empirical relation between economic deprivation and political stability. Consumption is the proportion of national economic resources which are allocated to consumers' goods. As a real world measure we will use the gross private consumption expenditures as a per cent of gross national product from the World Handbook of Political and Social Indicators.[24] In the simulate data sources we will use the level of consumption goods production expressed as a per cent of gross simulated product.

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[22] See Gurr, *op. cit.*, pp. 1107-1109, for a discussion of the construction of this index.

[23] Robert E. Pendley and Charles D. Elder, "An Analysis of Office-Holding in the Inter-Nation Simulation in Terms of Contemporary Political Theory and Data on the Stability of Regimes and Governments," (Evanston, Ill.: Simulated International Processes project, Northwestern University, November, 1966).

[24] Russett, *et al.*, pp. 170-171.

The variables in the second behavior area, economic growth, require less elaboration. The first variable in this area, growth, is an absolute measure of the change in the referent and simulate national product. Consequently, for real nations growth equals the annual increment in gross national product[25] and for simulate nations it is the period increment in gross simulated product.

The second variable in this group, growth rate, is simply the gross national or gross simulated product at time T+1 divided by the gross national or gross simulated product at time T. Hence when there is no change, growth rate will equal unity.[26]

The third variable is investment, and here we want to examine the proportion of the national and simulate product which is located in the investment sector. For the real world we again turn to the World Handbook for the series gross domestic capital formation as a per cent of gross national product.[27] As with consumption, our ratio will be investment goods produced over gross simulated product.

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[25]Absolute economic growth is the product of gross national product in 1957 in U.S. dollars (Ibid., pp. 152-154), annual growth of G.N.P. per capita (Ibid., pp. 160-161), and annual percentage of increase in population (Ibid., pp. 46-48). The indicator is transformed using $\log_{10}(x+1)$ transformation to reduce the skewness of the distribution.

[26]Growth rate equals annual growth of G.N.P. per capita (Ibid., pp. 160-161) times annual percentage of increase in population (Ibid., pp. 46-48).

[27]Ibid., pp. 168-169.

The third area, national security behavior, includes three variables: force capability, defense effort, and defense spending. The first of these, force capability, is an aggregate measure of the coercive power of a nation. In the real world we have taken the product of defense expenditures and size of their armed forces[28] as our indicator, and in the simulate worlds we will use total force capability as our measure.

Defense effort, like consumption and investment, is the proportion of the gross national or simulated product that is security goods. The real world data are taken from the World Handbook of Political and Social Indicators.[29] This variable may be thought of as a measure of relative defense spending.

Defense spending, the third and last in this group, in the real world is the amount a nation spends in its budget for defense, and in the simulate worlds we will use the amount of security goods produced in a period. The real world data again are taken from the World Handbook

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[28] This data is taken from the World Handbook of Political and Social Indicators. Force capability is the product of total population (Ibid., pp. 18-21), military personnel as a percentage of total population (Ibid., pp. 74-76), expenditure on defense as a percentage of G.N.P. (Ibid., pp. 79-80), and gross national product in US dollars (Ibid., pp. 152-154). The variable is $\log_{10}$ (x+1) transformed to make the distribution less skewed.

[29] Ibid., pp. 79-80.

<u>of Political and Social Indicators.</u>[30]

The last area of interest, which we have called international cooperation and conflict behavior, contains three variables. The first, relative trade, measures the relative importance of the foreign sector to the national economy. As our real world measure we will take the ratio of total exports and imports to gross national product,[31] and the ratio of total exports and imports to gross simulated product for the simulate nations.

Related to this is the variable trade magnitude, which is an absolute measure of international exchange. Here we simply use the numerator in the above measure as our indicator.[32]

Finally, we shall look at diplomatic conflict. This variable was one of the three basic dimensions of foreign conflict behavior delineated through a factor analysis of a variety of foreign conflict behavior.[33] The variables

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[30]Defense spending equals gross national product in US dollars (<u>Ibid</u>., pp. 152-154) times expenditure on defense as a percentage of G.N.P. (<u>Ibid</u>., pp. 79-80). Defense spending is $\log_{10}(x+1)$ transformed to make the distribution more normal.

[31]<u>Ibid</u>., pp. 164-165.

[32]Trade magnitude is the product of foreign trade as a percentage of G.N.P. (<u>Ibid</u>., pp. 164-165) and gross national product in US dollars (<u>Ibid</u>., pp. 152-154). A $\log_{10}(x+1)$ transformation is applied to the variable to make the distribution less skewed.

[33]R. J. Rummel, "Dimensions of Conflict Behavior Within and Between Nations," General Systems Yearbook, VIII (Washington: <u>Society for General Systems Research</u>, 1963), pp. 1-50.

which loaded most heavily upon this dimension included the sending of threats, accusations, and protests. We shall use Rummel's factor scores as a real world measure of diplomatic conflict.[34] In the SIPER data we have a variable which is analogous to diplomatic conflict, hostile communications sent. We shall take the total hostile communications sent to all nations as our measure of diplomatic conflict. A content analysis of all international communication in the INS runs was done, and we shall take the total number of messages sent in a period which were classed as a threat, accusation, or protest as a result of that analysis, as our INS diplomatic conflict indicator.[35]

Below is a summary list of the variables we will be examining.

Attribute Variables	Stability Variables
Size	Turmoil
Development	Conspiracy
Accountability	Internal War
	Stability
	Consumption

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[34] The factor scores are taken from the appendix of the above article.

[35] The analysis was carried out under the direction of Richard W. Chadwick. See Richard W. Chadwick, Definition of Simulation Threats, Accusations and Protests (Evanston, Ill.: Northwestern University Department of Political Science, April, 1965). The Inter-Nation Simulation data is from a set of runs conducted by John Raser and Wayman Crow at the Western Behavioral Sciences Institute. See their Winsafe II: An Inter-Nation Simulation Study of Deterrence Postures Embodying Capacity to Delay Response (La Jolla, Calif.: Western Behavioral Sciences Institute, July 31, 1964).

Growth Variables	Security Variables
Growth	Force Capability
Growth Rate	Defense Effort
Investment	Defense Spending

Cooperation and Conflict Variables

Relative Trade
Trade Magnitude
Diplomatic Conflict

It remains now for us to see how the attribute and behavior variables will be related in the referent, SIPER, and INS systems.

2. The Method of Analysis

We shall rely upon correlational analysis to generate our basic measures of correspondence. However, all the correlations listed in the following sections will be second order partial correlations. For example, when we examine the relationship between size and turmoil, we want first to partial out the effects of development and accountability. We can eliminate spurious correlations between attribute and behavior variables through spill-over effects by using partial correlation methods. In the tables that follow significance levels are given for the partial correlation coefficients when they are significant at .1 or less.

We will examine the significance patterns of the coefficients to compare the direction of correlation in each data source for each attribute-behavior pair. This procedure is similar to that which Chadwick used in his

validation work on the INS model.[36] We also use the more rigorous method of testing the hypothesis that there is no difference between the partial correlations from the three data sources for a given pair of variables.

Since the test is seldom used, we will elaborate on it here.[37] Both partial correlation coefficients are transformed in the following manner,

$$Zr = 1/2 \log_e \frac{(1 + r)}{(1 - r)}$$

The difference between the transformed coefficients has as its standard error

$$\sqrt{\frac{1}{N_1 - M_1 - 1} + \frac{1}{N_2 - M_2 - 1}}$$

where N_1 and N_2 equal the number of observations that correlations r_1 and r_2 are based on and M_1 and M_2 are the number of variables in the regression equation. In this case M_1 and M_2 are equal to 4, one dependent behavior variable and three attribute variables.

Dividing the difference between the transformed coefficients by its standard error in this fashion

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[36] Richard W. Chadwick, "Developments in a Partial Theory of International Behavior: A Test and Extension of INS Theory" (Unpublished Ph.D. dissertation, Department of Political Science, Northwestern University, 1966).

[37] Helen M. Walker and Joseph Lev, Statistical Inference (New York: Holt, Rinehart, and Winston, 1953), pp. 255-256. Extension of the test for simple correlations to partial correlations was aided by John Stapleton, chairman of the Department of Statistics at Michigan State University, and I wish to thank him for his assistance.

$$Z = \frac{Zr_1 - Zr_2}{\sqrt{\frac{1}{N_1 - M_1 - 1} + \frac{1}{N_2 - M_2 - 1}}}$$

produces the familiar Z statistic, which is an ordinate of the normal curve. In the following tables the differences between the partial correlations and the Z statistic of these differences are given, as is the significance level of the Z values.

A brief discussion of the nature of the samples used in this part of the evaluation is necessary. The real world data are drawn from several data sources, and the number of nations for which data are available ranges from 133 to 62, depending upon the variable. Reducing the sample down to nations about which we have complete information; i.e., a value for each of the behavior and attribute variables, leaves a sample of 41 nations. While this sample is not as large as one might wish, it should be sufficient for our purposes here. Table 10 lists those nations included in the sample. The sample nations tend to be a little larger, more developed, and more open, but the bias does not appear too large.

The sample drawn from the computer simulation data requires further elaboration. As was explained in the previous chapter, the simulation was used to produce twenty-four international systems. There were six different initial variable settings and four different parameter settings. The combinations thus produced were

TABLE 10

REAL WORLD NATIONS INCLUDED IN THE SAMPLE

United States	United Kingdom
Canada	Ireland
West Germany	France
Belgium	Netherlands
Italy	Switzerland
Sweden	Denmark
Norway	Finland
Portugal	Spain
Greece	Turkey
Yugoslavia	Soviet Union
Mexico	Guatemala
Cuba	Dominican Republic
Venezuela	Colombia
Ecuador	Brazil
Peru	Argentina
Chile	Israel
Ceylon	Burma
Thailand	Philippines
Japan	South Korea
Australia	New Zealand
South Africa	

twenty-four in number. In this part of the analysis we will ignore between-systems variance and treat the twenty-four systems as subsystems of one large international system. Later on in the next chapter we will want to examine specifically the between-systems variance, but our focus now is on the variance between nations.

Since there are five nations in each of the above systems-treated-as-subsystems, our n is 120 observations at any time point. We have chosen Period 7 as our time point for reasons to be discussed below.

In the Inter-Nation Simulation data we have six international systems which we shall treat as subsystems of a single international system. With five nations we then have an n of 30 to work with. Period 7 was chosen to give the systems time to develop but avoid ending effects. Ending effects do not, of course, occur in the computer simulation, but Period 7 was used to give the computer simulated worlds equal development time.

A final comment is required concerning the elaboration of empirical findings that follow. For the most part, theoretical elaboration of an attribute-behavior relationship will be given when either 1) there is a lack of internal consistency, i.e., the three data sources are in disagreement concerning the nature of the relationship under study, or 2) there is a lack of external consistency, i.e., the relationship reported here, particularly in the real world nations, is different from that reported elsewhere.

3. The Attribute and Stability Variables

The correlations between the attribute and stability variables are given in Table 11. If we decide that a correspondence exists between a simulate world and the real world when their respective correlation coefficients are both significantly greater than zero, or both not significantly different from zero, or both significantly less than zero, then the SIPER model produces corresponding relationships in eleven of the fifteen relationships under study and the INS model produces eight corresponding relations.[38] The correspondences and non-correspondences are distributed in the following ways.

	INS		
SIPER	Correspondence	Non-Correspondence	Total
Correspondence	7	4	11
Non-Correspondence	1	3	4
Total	8	7	15

It is clear that there is a tendency for both SIPER and INS to produce correct relationships at the same time, but it is worthy of note that when SIPER is right there is a stronger tendency for INS to be wrong than there is for SIPER to be wrong when INS is right. When SIPER is wrong in its predicted relationship, the error tends to be shared by INS. It would be premature to conclude that SIPER is

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[38]A relationship is considered significant if it is significant at the .10 level or less.

TABLE 11

CORRELATIONS BETWEEN ATTRIBUTE AND STABILITY VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
		Real	Siper	INS	Real	Siper	INS	Real	Siper	INS
Turmoil	r	.05	-.09	-.63	-.11	.08	.28	-.05	.09	-.17
	Sig			.0005						
Conspiracy	r	-.14	-.02	-.52	-.11	-.10	.28	-.32	.00	-.24
	Sig			.005				.049		
Internal War	r	-.18	.05	-.03	-.07	.02	.08	-.26	.03	-.32
	Sig									
Stability	r	.08	.12	.33	.13	-.09	-.04	.28	-.80	-.46
	Sig			.086				.082	.0005	.014
Consumption	r	-.13	.26	-.39	-.38	-.73	-.18	-.02	-.18	.19
	Sig		.004	.04	.017	.0005				

Sample size

Real	41
Siper	120
INS	30

r = second order partial correlation between the behavior variable listed on the left and the attribute variable listed above, controlling for the effects of the other attribute variables, in the data source listed above.

Sig = significance level of the coefficient if less than or equal to .10 for the test of the null hypothesis that r = 0.

more valid than INS at this stage, however.

Looking at the relationship between size and the behavior variables pertaining to political stability in Table 11, we find that in both SIPER and real world data no relationship is found between size and the first four stability variables, while the results are quite different for INS. The evidence that larger nations in INS experience less turmoil and conspiracy, though not less revolution, than smaller nations is quite strong. Revolutions are relatively rare in INS and 30 observations may not yield sufficient non-zero values for a pattern to emerge. The real world results reported here are in substantial agreement with Chadwick's findings.[39]

The general conclusion that size and the stability variables are unrelated in the SIPER and referent worlds is supported by the correlation between size and stability given in Table 11.[40] Again, however, larger nations in INS show a moderate tendency to be more stable than smaller nations. The relationship is, however, a weak one since

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[39] Richard W. Chadwick, "An Inductive, Empirical Analysis of Intra- and International Behavior, Aimed at a Partial Extension of Inter-Nation Simulation Theory," Journal of Peace Research, No. 3 (1969), pp. 193-214. Chadwick reports a correlation of -.18 between BC (size) and VSm (turmoil), which is not significant at the .05 level, and a correlation of -.17 between BC (size) and pR (conspiracy), which is not significant at the .05 level.

[40] Chadwick, op. cit., p. 197, reports a correlation of .18 between BC (size) and pOH (stability), which is not significant at the .05 level.

TABLE 12

COMPARISONS OF CORRELATIONS FOR ATTRIBUTE AND STABILITY VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
	' "	Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS
Turmoil	r'-r"	.14	.68	.54	-.19	-.39	-.20	-.14	.12	.26
	Z	0.74	3.04**	2.95**	-1.00	-1.53	-0.94	-0.74	0.47	1.19
Conspiracy	r'-r"	-.12	.38	.50	-.01	-.39	-.38	-.32	-.08	.24
	Z	-0.64	1.67*	2.52**	-0.05	-1.53	-1.76*	-1.74*	-0.33	1.11
Internal War	r'-r"	-.23	-.15	.08	-.09	-.15	-.06	-.29	.06	.35
	Z	-1.22	-0.58	0.36	-0.47	-0.58	-0.27	-1.55	0.25	1.64
Stability	r'-r"	-.04	0.25	-.21	.22	.17	-.05	1.08	.74	-.34
	Z	-0.21	-1.01	-1.01	1.16	0.66	-0.23	7.27**	3.02**	-2.73**
Consumption	r'-r"	-.39	.26	.65	.35	-.20	-.55	.16	-.21	-.37
	Z	-2.10*	1.08	3.10**	2.77**	-0.84	-3.99**	0.85	-0.82	-1.70*

r'-r" = the difference between the partial correlations of the behavior variable on the left and the attribute variable listed above found in the data sources listed as ' and " above.

$$Z = \frac{1/2 \log_e \frac{1+r'}{1-r'} - 1/2 \log_e \frac{1+r''}{1-r''}}{\sqrt{\frac{1}{N'-5} + \frac{1}{N''-5}}}$$

* = difference significant at the .05 level
** = difference significant at the .01 level

in Table 12 we find that the difference between the real world and INS world correlations is not significant at the .05 level.

The last behavior variable that we have related to size is consumption. There is no relationship in the real world, a positive relationship in the SIPER worlds, and a negative relationship in the INS worlds. The real world relationship deserves further discussion. Russet, et al., have reported a correlation of -.24 between total population (size) and private consumption as a percentage of G.N.P. (consumption).[41] This correlation is significant at the .05 level. It appears that the relationship between size and consumption disappears when the level of development is held constant. Chadwick reports a positive correlation (.87) between BC (size) and CS,[42] but since CS is an absolute measure of consumption, it seems likely that this correlation is a result of the effect of size. That is, large nations must spend more on consumption measured in absolute terms than smaller nations. Here we are concerned with relative consumption levels.

There are a number of explanations that could be put forth for the lack of correspondence, but discussion of

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[41]Russett, et al., op. cit., p. 278.

[42]Chadwick, op. cit., p. 197.

this discrepancy should be postponed until the variables of investment and defense effort are considered, since consumption, investment, and defense effort are so tightly linked. In INS and SIPER these variables must always sum to one. We will discuss these three variables in detail in section 7 below. It should be noted, however, that the difference between the referent and INS correlations is not significant at the .05 level, while the difference between the referent and SIPER correlations is significant at the .05 level. (See Table 12.)

The relationships between the level of development and the first four measures of political stability are noteworthy. In all three data sources the relationships are found not to be significantly different from zero at the .10 level of significance. The correlations in all cases are quite low, and these findings are in conformity with Russett's and Taylor's conclusion that "we know of no study that produced a correlation that exceeded .75 between economic development and any political variable of interest."[43] Feierabend and Feierabend, however, report a positive relationship between per capita G.N.P. and political stability.[44] But the analysis here indicates that the simple correlations between development and turmoil (-.18),

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[43]Bruce M. Russett and Charles L. Taylor, "Is Political Instability Related to Per Capita Income?," Bendix Corporation Working Paper No. 97 (Ann Arbor: Bendix Corporation, January 23, 1967), p. 6.

[44]Feierabend and Feierabend, _op_. _cit_., p. 260.

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conspiracy (-.38), internal war (-.30), and stability (.32), the latter three being significant at the .05 level, do not hold up once the effects of size and degree of accountability are controlled for. This supports partially Russett's and Taylor's conclusion that "...other social and political factors, in addition to economic development, are at work."[45]

Agreement about the relationship between consumption and development is not found. Both the referent and SIPER worlds show consumption to be negatively related to the level of development, while no relationship emerges in the INS worlds.[46] However, the SIPER correlation is significantly different from the real world and INS correlations, while the latter correlations are not significantly different at the .05 level. Again, discussion of consumption is postponed for reasons indicated above.

With regard to the attribute of accountability, we find agreement in the three data sources about its relation to turmoil. None of the coefficients is significant at the .10 level and a check of Table 12 indicates there is no significant difference between the coefficients at the .05 level.[47]

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[45]Russett and Taylor, op. cit., p. 7.

[46]Russett, et al., op. cit., p. 278, report a correlation of -.44, which is significant at the .001 level, between private consumption as a percentage of G.N.P. and per capita G.N.P.

[47]Chadwick, op. cit., p. 197, reports a similar correlation of -.03 between DL (accountability) and VSm (turmoil).

This cannot be said about the relationship between accountability and conspiracy, however. Real world nations which are more open experience less conspiracy than those which are more closed.[48] This relationship is not found among the simulated nations. The relationship found in INS is more like the real world relationship than is SIPER's, and the difference between INS and the real world is not significant at the .05 level, according to Table 12.

Nevertheless, there appears to be a tendency for a real world relationship not to be replicated in the simulated worlds. According to the INS programmed hypothesis, which is shared by SIPER, there should be a relationship between accountability and conspiracy. In section 2 of Chapter II, we indicated that the probability of revolution (PR), the conspiracy measure, is positively related to the degree of decision latitude (DL), which is the accountability measure inverted. Consequently, we would expect a negative correlation between conspiracy and accountability. The fact that one does not emerge testifies to the character of complex models. Obviously other factors are cancelling out the effects of this particular relationship, and it is not readily apparent what these are.

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[48] Chadwick, op. cit., p. 197, finds no relationship between DL (accountability) and pR (conspiracy), ($r = .08$). Since the simple correlation found here between accountability and conspiracy is -.45, it appears that Chadwick's indicator of pR, number of attempted revolutions, measures a specific kind of conspiratorial behavior rather than the more general measure developed by Gurr, which is used here.

It is clear that the hypothesis relating conspiracy and accountability needs reformulation. Gurr's work, "A Causal Model of Civil Strife,"[49] is suggestive of the direction that this revision should take. In his revised model we find two variables that seem to share some of the aspects of our accountability variable, institutionalization and legitimacy. The simple correlations between conspiracy and these variables are -.35 and -.29 respectively,[50] a level of correlation not too different from the -.32 correlation we find between accountability and conspiracy in Table 11. It is clear that a revision of both INS and SIPER is needed to include the effects of accountability on the level of conspiracy behavior that a nation experiences, since there is both theoretical and empirical evidence for its inclusion.

Accountability and internal war are similarly unrelated. A relationship between these variables is absent in all three data sources, as indicated in Table 11. Furthermore, Table 12 shows that the coefficients are not significantly different from one another at the .05 level of significance.

The same cannot be said for the relationship between accountability and stability. In real world nations there is a slight tendency for open nations to be more stable, while the opposite relationship holds quite strongly in the

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[49] Gurr, _op_. _cit_., pp. 1104-1124.

[50] _Ibid_., p. 1119.

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simulated worlds.[51] The differences between all three of the coefficients in Table 11 are significant at the .01 level, as indicated in Table 12, but we will be most concerned with the differences between the real world and the simulated worlds.

An examination of the programmed hypothesis that relates stability to accountability, which is common to both SIPER and INS, shows clearly why the real world relationship does not emerge in the simulated worlds. The hypothesis states that stability (POH) is positively related to validator satisfaction overall (VSm) and positively related to decision latitude (DL), but negatively related to the multiplicative interaction of the two variables.[52]

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[51]Chadwick, op. cit., p. 197, reports the opposite relationship. He found a positive relationship between DL (inverted accountability) and pOH (stability), ($r = .30$, significant at the .05 level). Chadwick's indicator of pOH is the average age of the last two governments. This choice of indicator seems to reflect a conceptualization of stability as the absence of change (see note 21), rather than the one used here, the absence of destabilizing events (see note 20). The lack of intercorrelation between indicators of political stability has been discussed by Russett and Taylor, with the conclusion that "empirically, there is no single dimension of political stability...that measures satisfactorily all the phenomena we would like to know about." Op. cit., pp. 5-6.

[52]The mathematical formulation for this relationship is $POH = abVSm - a(DL)(VSm) + cDL - cd$, but the verbal statement of the relationship is simply "the higher the decision-latitude, the less immediately is office-holding subject to validator satisfaction;" a statement which does not necessarily require the interaction term in the above equation. Guetzkow, op. cit., pp. 115-116.

Since we are using a negatively transformed decision-latitude as our measure of the accountability of the simulate nations, we would expect stability and accountability to be negatively related.

In view of the empirical evidence gathered from real world data it would appear that the relationship between accountability and stability postulated by INS theory is improperly framed. However, the weak relationship found in the real world suggests that a reversal of the effect of accountability on stability will not be adequate, but rather that further study of the real world relationships is required before a revision may be proposed. Again we add that such a revision would rely partially on Gurr's work.[53]

The last relationship to be considered in this section involves accountability and consumption. We find no relationship between these variables in the real and INS worlds, but a negative relationship does emerge in the SIPER data.[54] This is a perplexing correlation since there is no a priori reason why the model should produce such a relationship in any direct way. There are two factors

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[53]Gurr, op. cit., pp. 1104-1124.

[54]Chadwick, op. cit., p. 197, reports a negative correlation between DL (inverse accountability) and CS, absolute consumption (r = -.35, significant at the .01 level). This would suggest a positive relationship between accountability and the absolute level of private consumption. We are concerned here with relative levels of consumption, however.

which should be kept in mind, however. First, the difference between the real world correlation and the SIPER correlation is not significant at the .05 level (see Table 12), although INS and SIPER are significantly different. Second, the interdependence of consumption, investment, and defense effort, as indicated earlier, raises the possibility that the correlation we have here is a result of a faulty relationship in the growth or security areas. For this reason we shall want to reexamine this relationship in section 7.

4. The Attribute and Growth Variables

Tables 13 and 14 give the relevant information concerning the correlations between the three attribute and three growth variables. The correspondence score for the simulation worlds is as follows.

	INS		
SIPER	Correspondence	Non-Correspondence	Total
Correspondence	2	3	5
Non-Correspondence	2	2	4
Total	4	5	9

These aggregate results are too mixed to interpret except to say that with regard to these relationships there appears to be no reason to judge one model as being superior to another. It may prove more profitable to examine each of the attribute-behavior pairings in turn, as was done in the previous section.

TABLE 13

CORRELATIONS BETWEEN ATTRIBUTE AND GROWTH VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
		Real	Siper	INS	Real	Siper	INS	Real	Siper	INS
Growth	r	.87	.33	.13	.62	-.09	.21	.05	-.15	.33
	Sig	.0005	.0005		.0005					.085
Growth Rate	r	.39	.24	.15	-.30	.05	.15	.09	-.08	.21
	Sig	.014	.009		.065					
Investment	r	-.05	.44	.21	.21	-.17	-.06	.07	-.03	.25
	Sig		.0005			.072				

Sample size

Real	41
Siper	120
INS	30

r = second order partial correlation between the behavior variable listed on the left and the attribute variable listed above, controlling for the effects of the other attribute variables, in the data source listed above.

Sig = significance level of the coefficient if less than or equal to .10 for the test of the null hypothesis that r = 0.

TABLE 14

COMPARISONS OF CORRELATIONS FOR ATTRIBUTE AND GROWTH VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
	' "	Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS
Growth	r'-r"	.54	.74	.20	.71	.41	-.30	.20	-.28	-.48
	Z	5.20**	4.62**	0.96	4.28**	1.97*	-1.38	1.06	-1.08	-2.19*
Growth Rate	r'-r"	.15	.24	.09	-.35	-.45	-.10	.17	-.12	-.29
	Z	0.88	1.16	0.43	-1.89*	-1.77*	-0.46	0.89	-0.47	-1.33
Investment	r'-r"	-.49	-.26	.23	.38	.27	-.11	.10	-.18	-.28
	Z	-2.74**	-1.01	1.18	2.02*	1.05	-0.51	0.53	-0.71	-1.29

r'=r" = the difference between the partial correlations of the behavior variable on the left and the attribute variable listed above found in the data sources listed as ' and " above.

$$Z = \frac{1/2 \log_e \frac{1+r'}{1-r'} - 1/2 \log_e \frac{1+r''}{1-r''}}{\sqrt{\frac{1}{N'-5} + \frac{1}{N''-5}}}$$

* = difference significant at the .05 level

** = difference significant at the .01 level

We find from an inspection of the first three columns in Table 13 that larger nations in both the real and SIPER worlds have greater absolute growth and higher growth rates. As indicated in Table 14, however, the relationship between size and absolute growth is much stronger in the real world than in the SIPER world. In addition, it should be noted that the difference in the coefficients of correlation between size and absolute growth of the SIPER and INS worlds is not significant at the .05 level. Furthermore, the differences between the correlations of size and growth rate are not significantly different for all three data sources, as indicated in Table 14. Nevertheless, it is clear that SIPER is producing a behavior pattern like that found in the real world, while INS is not.[55]

Turning to the relationship between size and investment, we find no significant relationship in the real or

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[55]Kuznets has noted "...small countries are under a greater handicap than large in the task of economic growth. Their small size may not permit them to take full advantage of the potential of large-scale production and organization; their defence task vis-a-vis the rest of the world may be proportionately greater; and their reliance on international trade and international division of labour, while greater than for large countries, must still be limited for security reasons, and because many needed goods that are closely interwoven with the country's distinctive culture and indigenous life cannot be imported." Simon Kuznets, "Economic Growth of Small Nations," The Economic Consequences of the Size of Nations, ed. A. Robinson (New York: St. Martin's Press, 1965), p. 20.

INS worlds, but we do find a strong positive relationship in the SIPER worlds. As per our discussion of size and consumption, we would like to postpone further consideration of this relationship to section 7.[56]

With regard to the relationship between development and growth, it will be noted that a very strong positive relationship appears in the real world data and no such relationship appears in the SIPER and INS data. The explanation in the case of the SIPER model would appear to be that there is a tendency for the decision-making rules to cut back the amount of investment when the rate of return on the investment is higher, rather than aiming for a higher return. There is, in fact, a weak negative relationship between investment and development, as indicated in Table 13, in the SIPER data. In other words, when it is relatively easy for a SIPER nation to produce increments in its national wealth, the tendency is for the nation to reduce the amount of resources allocated to achieving economic growth and have less absolute growth than it would have

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[56]It should be noted, however, that according to Ragnar Nurske, "the inducement to invest is limited by the size of the market. In the exchange economy of the real world, it is not difficult to find illustrations of the way in which the small size of a country's market can discourage, or even prohibit, the profitable application of modern capital equipment by any individual entrepreneur in any particular industry." Ragnar Nurske, "The Size of the Market and the Inducement to Invest," Development and Society, eds. D. E. Novack and R. Lekachman (New York: St. Martin's Press, 1964), pp. 92-93. This proposition would support the results produced by SIPER.

if it took advantage of its higher productivity and produced more absolute growth by not reducing its investment allocation. One might, in a sense, call the model lazy with respect to absolute growth. In the revision we shall want to rectify this tendency.

The relationship between development and the rate of growth is an interesting one also. In real world nations there is a weak negative relationship between development and growth rate, and no relationship at all in INS and SIPER. The difference between the real world and SIPER coefficients and the real world and INS coefficients are both significant at the .05 level, while INS and SIPER are not significantly different.

While the real world relationship is not a strong one, one might postulate that the aspiration level for growth is higher for less developed countries than for more developed countries and that this factor produces policy choices in less developed countries which result in higher growth rates. Organski suggests that less developed nations put a higher priority on growth than more developed nations.[57] It may be that a factor in the setting of the aspiration level in these countries is the desire to catch up to the more developed countries, rather than merely staying even with other countries of the same approximate

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[57] A. F. K. Organski, The Stages of Political Development (New York: Alfred A. Knopf, 1965).

size.[58] The latter factor is included in the SIPER rule for setting the aspiration level for economic growth, but the former is not. We may want to include the "catch up" factor in the growth aspiration mechanism in the future.

We have previously discussed the relationship between development and investment when we talked about development and absolute growth, and we will reconsider it in section 7.[59]

The last attribute variable we want to look at, accountability, is not related to any of the growth behavior variables in the real or SIPER worlds. The relationship between accountability and growth is a weak positive one in INS, but the difference between the correlation in the real world and the correlation in the INS world is not significant at the .05 level.

These findings are generally in agreement with those of Adelman and Morris that political variables are of marginal importance in explaining different rates of economic growth.[60]

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[58] Robert North gives some support to this also. See his "Steps Toward Developing a Theory," Studies in International Conflict and Integration, April 24, 1967, ditto.

[59] In regard to the relationship between investment and development, Jacob Viner has stated, "it may also be true that as average income through time increases, the percentage of the national income which will be annually saved will increase. But empirical evidence in support of this is lacking, and there are some a priori reasons for being skeptical about it." Jacob Viner, "Barriers to Economic Development," D. E. Novack and R. Lekachman, _op. cit._, p. 83.

[60] Irma Adelman and Cynthia Taft Morris, _op. cit._ See also Andreas C. Tsantis, "Political Factors in Economic Development," _Comparative Politics_, Vol. 2, No. 1 (October, 1969), pp. 63-78.

5. The Attribute and Security Variables

The information concerning the correlations among this group of variables is given in Table 15. Defining correspondence as we have in the past, that is, as the mutual confirmation of a positive, negative, or zero relation by the real world and a simulate source, the correspondences of SIPER and INS are distributed like this.

	INS		
SIPER	Correspondence	Non-Correspondence	Total
Correspondence	3	2	5
Non-Correspondence	2	2	4
Total	5	4	9

SIPER and INS have the same number of aggregate mis-predictions, but they are not necessarily wrong on the same relationships.

All three data sources concur that there is a strong relationship of a positive nature between force capability and size.[61] All the correlations are quite high, and the differences between them are not significant at the .05 level of significance. (See Table 16.)

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[61]Chadwick, op. cit., p. 197, reports a strong positive association between BC (size) and FC (force capability). In addition, Haas and Whiting have commented, "human resources, combined with physical foundations and industrial production, determine the amount of power available to the policy maker in support of means." Dynamics of International Relations (New York: McGraw-Hill Book Company, 1956), pp. 133-134.

TABLE 15

CORRELATIONS BETWEEN ATTRIBUTE AND SECURITY VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
		Real	Siper	INS	Real	Siper	INS	Real	Siper	INS
Force Capability	r	.65	.50	.72	.61	.64	.42	-.33	.01	.18
	Sig	.0005	.0005	.0005	.0005	.0005	.027	.039		
Defense Effort	r	.36	-.41	.08	.53	.74	.17	-.44	.22	-.46
	Sig	.026	.0005		.001	.0005		.005	.018	.015
Defense Spending	r	.78	.32	.88	.74	.74	-.07	-.29	.27	-.35
	Sig	.0005	.0005	.0005	.0005	.0005		.071	.004	.069

Sample size

Real	41
Siper	120
INS	30

r = second order partial correlation between the behavior variable listed on the left and the attribute variable listed above, controlling for the effects of the other attribute variables, in the data source listed above.

Sig = significance level of the coefficient if less than or equal to .10 for the test of the null hypothesis that r = 0.

TABLE 16

COMPARISONS OF CORRELATIONS FOR ATTRIBUTE AND SECURITY VARIABLES

BEHAVIOR	' / "	ATTRIBUTE: Size			Development			Accountability		
		Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS	Real Siper	Real INS	Siper INS
Force Capability	r'-r"	.15	-.07	-.22	-.03	.19	.22	-.34	-.51	-.17
	Z	1.19	-0.51	-1.63	-0.26	1.00	1.41	-1.85*	-2.02*	-0.78
Defense Effort	r'-r"	.77	.28	-.49	-.21	.36	.57	-.66	.02	.68
	Z	4.27**	1.14	-2.34**	-1.89*	1.61	3.53**	-3.65**	0.10	3.27**
Defense Spending	r'-r"	.46	-.10	-.56	.00	.81	.81	-.56	.06	.62
	Z	3.74**	-1.27	-4.73**	0.00	3.92**	3.92**	-3.02**	0.26	2.91**

r'-r" = the difference between the partial correlations of the behavior variable on the left and the attribute variable listed above found in the data sources listed as ' and " above.

$$Z = \frac{1/2 \text{ loge } \frac{1+r'}{1-r'} - 1/2 \text{ loge } \frac{1+r''}{1-r''}}{\sqrt{\frac{1}{N'-5} + \frac{1}{N''-5}}}$$

* = difference significant at the .05 level
** = difference significant at the .01 level

Similarly, we find agreement concerning the positive relationship between size and the absolute level of defense allocation, defense spending. Table 16 shows that the relationship in SIPER is weaker, however.

The agreement which characterizes the relationships discussed above is clearly not found in the matter of size and defense effort. Real world nations which are larger spend proportionately more on defense than those which are smaller, while the reverse holds in the SIPER nations. Large INS nations, on the other hand, allocate neither relatively more nor relatively less to defense than smaller nations. The major difference, as can be seen in Table 16, is between SIPER and the real world, however. In section 7 we will consider this problem at length along with the consumption and investment variables.

Development and force capability are positively related in all three worlds and the differences between the coefficients are not significant at the .05 level, even though the relationship in INS is somewhat weaker.

Table 15 indicates that more developed nations spend relatively nore on defense than less developed nations in both SIPER and the real world, but there appears to be no relationship between development and defense effort in the INS world. Table 16 indicates, however, that the relationship found in the SIPER nations is significantly stronger at the .05 level than the real world relationship. The nature of the real world correlation deserves elaboration.

Russett in his study of nations concluded that "no relationship was found between the military expenditure ratio and G.N.P. per capita..."[62] Although Russett gives no coefficient of correlation for the two variables, it is probably not significantly different from the zero order correlation of .33 found in the present sample of 41 nations. All of these nations, by the way, were in Russett's sample of 82. Russett's finding was confirmed by Frederic L. Pryor for the NATO and Warsaw Treaty nations.[63] How is this discrepancy to be explained? The simple correlations between defense effort and size, development and accountability are .43, .33, and -.16 respectively. Only the first of these is highly significant. The partial correlations, on the other hand, are .36, .53, and -.44 respectively for the variable pairs. When we add to this the fact that the level of development is positively related to the degree of accountability (.62), it becomes clear why others have not found the relationships reported here. The more developed a nation is, the more, relatively speaking, it spends on defense; but the more developed it is, the more open it is likely to be and the less it will spend on defense in relative terms. Hence, there are two contrary

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[62] Bruce M. Russett, "Measures of Military Effort," American Behavioral Scientist (February, 1964), p. 29.

[63] Frederic L. Pryor, Public Expenditures in Communist and Capitalistic Nations (Homewood, Ill.: Irwin, 1969), p. 93.

forces at work, and it is only through partial correlation that we are able to see their separate effects.

A similar pattern of SIPER correspondence and INS non-correspondence is found in the relationship between development and defense spending. The real world and the SIPER world nations spend more on defense in absolute terms if they are developed than if they are undeveloped. There is, on the other hand, no relationship of this kind in the INS nations, and, as Table 16 indicates, the INS correlation is significantly different from both the real and SIPER correlations at the .01 level.

The relationships between accountability and force capability constitute non-correspondences for both SIPER and INS. The real world relationship is a negative one, while there is no evidence to infer a non-zero relationship in INS or SIPER.[64] Both the INS and SIPER coefficients are significantly different from the real world coefficient at the .05 level, though they are not significantly different from one another. The explanation for this divergence may reside in the relationship between force capability and internal strife. In INS and SIPER decision-makers may reduce the probability of domestic strife by increasing the proportion of force capability allocated to internal security, but an increase in the absolute size of force capability

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[64] Chadwick, op. cit., p. 197, reports a real world correlation of -.03 between DL (inverse accountability) and FC (force capability).

does not, per se, decrease internal threats. Hence, simulate nations gain little domestic security from maintaining large force capabilities regardless of the degree to which they are open or closed. Real world nations, on the other hand, which are more closed, may find it beneficial and necessary to maintain large internal security forces. It has been often suggested, for example, that the national military establishments in Latin American countries are intended to preserve internal as much as external security. It is probable that we are capturing the effects of closed real world nations maintaining large force capabilities for internal security pruposes. Chadwick has found that "highly responsive political systems tend to use relatively little coercion..."[65] Less responsive political systems may rely on "authoritarian stabilization" and consequently maintain larger armed forces.[66] A revision of the INS conceptualization along the lines suggested by Gurr as indicated earlier is likely to improve correspondence.[67]

The remaining two behavior variables in this area of behavior, defense effort and defense spending, are related in a similar fashion to the attribute of accountability in

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[65] Chadwick, *op. cit.*, p. 207.

[66] Gabriel Almond, "Research Note: A Comparative Study of Interest Groups and the Political Process," *American Political Science Review*, Vol. LII, No. 1 (March, 1958).

[67] Gurr, *op. cit.*

all the data sources. In real world and INS nations the pattern is for nations which are less open to spend relatively and absolutely more on defense than those which are more open. The opposite relationship is found to characterize the SIPER nations, however.

This relationship in the SIPER data is unexpected, and the source of error is difficult to locate within the computer model at this time. Since consumption, investment, and defense effort are interdependent decisions we need to view these facets of behavior together since an error in one will necessarily produce an error in at least one other facet of behavior. Hence, we will consider these three behavior variables in more detail in section 7.

6. The Attribute and Cooperation and Conflict Variables

Table 17 presents the relationships found between the measures of international cooperative and conflictual behavior and the attribute variables for each data source. Table 18 provides the relevant information for comparing the coefficients, as in past sections.

The correspondence score, as defined in the past, for the two simulations is as follows:

	INS		
SIPER	Correspondence	Non-Correspondence	Total
Correspondence	2	4	6
Non-Correspondence	1	2	3
Total	3	6	9

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Charles

TABLE 17

CORRELATIONS BETWEEN ATTRIBUTE AND COOPERATION-CONFLICT VARIABLES

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
		Real	Siper	INS	Real	Siper	INS	Real	Siper	INS
Relative Trade	r	-.63	-.01	-.06	.12	-.29	-.03	.01	-.08	.19
	Sig	.0005				.001				
Trade Magnitude	r	.74	.50	.08	.74	-.12	.07	.06	.00	.30
	Sig	.0005	.0005		.0005					
Diplomatic Conflict	r	.12	.06	-.35	.34	.29	-.08	-.26	.06	-.36
	Sig			.062	.037	.001				.063

Sample size

Real 41
Siper 120
INS 30

r = second order partial correlation between the behavior variable listed on the left and the attribute variable listed above, controlling for the effects of the other attribute variables, in the data source listed above.

Sig = significance level of the coefficient if less than or equal to .10 for the test of the null hypothesis that r = 0.

TABLE 18

COMPARISONS OF CORRELATIONS FOR ATTRIBUTE AND COOPERATION-CONFLICT VARIABLES

BEHAVIOR	' / "	Size: Real / Siper	Size: Real / INS	Size: Siper / INS	Development: Real / Siper	Development: Real / INS	Development: Siper / INS	Accountability: Real / Siper	Accountability: Real / INS	Accountability: Siper / INS
Relative Trade	r'-r"	-.62	-.57	.05	.41	.15	-.26	.09	-.18	-.27
	Z	-3.84**	-2.62**	0.23	2.20*	0.58	-1.22	0.47	-0.70	-1.24
Trade Magnitude	r'-r"	.24	.66	.42	.86	.67	-.19	.06	-.24	-.30
	Z	2.11*	3.35**	2.13*	5.55**	3.38**	-0.87	0.32	-0.96	-1.40
Diplomatic	r'-r"	.06	.47	.41	.05	.42	.37	-.32	.10	.42
	Z	0.32	1.87*	1.93*	0.29	1.67*	1.72*	-1.71*	0.43	1.98*

r'-r" = the difference between the partial correlations of the behavior variable on the left and the attribute variable listed above found in the data sources listed as ' and " above.

$$Z = \frac{1/2 \log_e \frac{1+r'}{1-r'} - 1/2 \log_e \frac{1+r''}{1-r''}}{\sqrt{\frac{1}{N'-5} + \frac{1}{N''-5}}}$$

* = difference significant at the .05 level.
** = difference significant at the .01 level.

This evidence suggests that in aggregate sense SIPER is superior to INS, but it is necessary to consider each of the nine relationships before a conclusion can be reached.

Both SIPER and INS differ from the real world with respect to the relationship of relative trade to size. The negative relationship between size and relative trade has been observed by others, notably Deutsch, Bliss, and Eckstein. The observed curvilinear relationship was stated thusly,

> ...the foreign trade ratio tends to decline only moderately...as country sizes increase from about 1 million to about 10 million.... This decline is accelerated, however, at population sizes above 10 million.[68]

Kuznets similarly says that "...the ratio of foreign trade to national income rises as the average size of population declines."[69] The reasons for this have been elaborated elsewhere.[70] Economies of scale enter the foreign trade decisions in such a way as to reduce the advantage of international exchange, relatively speaking. In the SIPER model the amount of national trade which the nation desires to engage in is given as a constant proportion of size

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[68] Karl W. Deutsch, Chester I. Bliss, and Alexander Eckstein, "Population, Sovereignty, and the Share of Foreign Trade," Economic Development and Cultural Change, Vol. 10 (July, 1962), pp. 353-366.

[69] Kuznets, *op. cit.*, p. 20.

[70] Hollis B. Chenery, "Patterns of Industrial Growth," American Economic Review (November, 1960), pp. 124-54.

rather than a decreasing proportion. A revision of this formulation to include a curvilinear relationship will remedy this non-correspondence.

Both SIPER and real world nations trade more in absolute terms as their size increases, while INS nations do not.[71] There are differences between the strengths of relationship between real world, SIPER, and INS nations, as can be seen from Table 18; however, on the whole, SIPER's performance is satisfactory in this regard.

With respect to the relationship between size and diplomatic conflict we find the real and SIPER data sources in substantial agreement about the absence of a relationship.[72]

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[71]Chadwick, op. cit., p. 197, reports correlations of .85 between BC (size) and imports and .79 between BC (size) and exports for the real world.

[72]However, Rummel finds significant correlations between population (size) and threats (.32), accusations (.36), and protests (.38), which are significant at the .01 level. In spite of this Rummel concludes "there is little relationship between a nation's power and its foreign conflict behavior." Rudolph J. Rummel, "The Relationship Between National Attributes and Foreign Conflict Behavior," Quantitative International Politics, ed. J. David Singer (New York: The Free Press, 1968), p. 208. The preliminary work of Salmore and Hermann indicates that of the three variables, size, development, and accountability, size is best in accounting for what variation in conflict that is explained by the three variables. Regretably, the partial correlations are not now available for comparison. Stephen A. Salmore and Charles F. Hermann, "The Effect of Size, Development, and Accountability on Foreign Policy," prepared for delivery at the Seventh North American Peace Research Conference of the Peace Research Society (International), University of Michigan, Ann Arbor, Michigan, November 11-12, 1969.

However, in INS we find a weak inverse relationship, but one which is significantly different from the relationships found in real and SIPER worlds according to Table 18. Smaller INS nations are the source of more diplomatic conflict than larger INS nations.

Considering the relationship between a nation's level of development and its relative trading activity, we find that in real world and INS data the relationship is absent, while more developed SIPER nations exhibit a tendency to trade relatively less.[73] Interestingly enough, this is precisely the relationship that economic historian Werner Sombart proposed.[74] Karl Deutsch and Alexander Eckstein have empirically investigated this "law of the declining importance of foreign trade."[75] Their findings with respect to real world nations do not support our findings with respect to real world nations, but rather agree with our findings in the SIPER data. Deutsch and Eckstein, using time series data, rather than cross-sectional data such as ours is, found a clear trend towards a reduction in the relative size of the foreign trade sector as industrialization

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[73]Kuznets has commented, "...there is no clear association between the ratio of foreign trade to income (relative trade) and per capita income (development)." Kuznets, op. cit., p. 20.

[74]Werner Sombart, Die Deutsche Volkswirtschaft in Neunzehnten Jahrhundert (Berlin: Bondi, 1913, Third edition), pp. 368-376, 528.

[75]Karl W. Deutsch and Alexander Eckstein, "National Industrialization and the Declining Share of the International Economic Sector, 1890-1959," World Politics, Vol. 13, No. 2 (January, 1961), pp. 267-299.

However, in 198 [illegible]
and [illegible]
found in [illegible]
[illegible]
[illegible]

advanced. The relationship is not strictly linear, however, since there is a slight increase in trade in the early stages of industrialization.

The fact that the SIPER model produces a relationship in cross-sectional data which appears in longitudinal real world data must be considered at least a partial correspondence.

We are not so fortunate, however, with respect to the relationship between development and the absolute size of the foreign trade sector. Real world nations which are more developed trade more, in absolute terms, than those which are smaller, while the level of development of SIPER and INS nations is not related to the absolute size of their foreign trade sector.

This finding seems to suggest that rethinking of the decision processes governing the amount of trade is necessary, as was previously noted. In the reformulation of trade volume decision processes, as discussed above, we shall have to carefully examine the role of development in the processes.

Examining the relationship between development and diplomatic conflict we find SIPER and the real world in substantial agreement that developed nations engage in diplomatic conflict more than undeveloped nations.[76] A

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[76]Rummel finds little relationship between development and threats, accusations, and protests and concludes that there is "little relationship between a nation's economic development or level of technology and its foreign conflict behavior." op. cit., p. 205.

similar relationship is not found in the INS data, according to Table 17. Furthermore, INS is significantly different from both SIPER and the real world in this respect, as shown in Table 18, while SIPER and the real world are not significantly different at the .05 level.

With respect to the relationships between the attribute of accountability and our cooperative behavior variables, relative trade and trade magnitude, we can report agreement among the three data sources that there is no relationship between these variables.[77] It is an interesting finding that real nations that are more politically open are not necessarily more economically open, from an international point of view.

Finally we observe, as reported in Table 17, the absence of a significant relationship between accountability and diplomatic conflict in the real and SIPER worlds.[78] INS nations, on the other hand, which are closed show a moderate tendency to be the source of more diplomatic conflict than those which are open. We find, however, that the real world relationship is approaching significance in

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[77]However, Chadwick, _op_. _cit_., p. 197, finds a negative relationship between DL (inverse accountability) and imports (r = -.35) and exports (r = -.33). Both of these are significant at the .01 level. Further confirmation of either of these results has not been found.

[78]We are in substantial agreement here with Rummel that "the degree of totalitarianism of a government has little relationship to its foreign conflict behavior." _op_. _cit_., p. 207.

similar relationship is not found in the LD data, accord-

ing to Table 17

different

as shown

not

the same direction, and, as Table 18 shows, the INS and real world coefficients are not significantly different at the .05 level, while SIPER differs from both INS and the real world at this level of significance.

7. National Attributes and National Allocations

We have in earlier sections indicated that some special attention is due to three behavior variables: consumption, investment, and defense effort. Indeed, these three behavior variables account for nearly one-half of the non-correspondences of the SIPER model reported in earlier sections.

In Table 19 we have reproduced the entries relevant to these three variables from Tables 11, 13, and 15. As this table shows, larger SIPER nations spend relatively more on consumption and investment and relatively less on defense than smaller SIPER nations. Larger INS nations spend relatively less on consumption, but there is no clear evidence as to where the surplus is allocated. Real nations, on the other hand, spend relatively more on defense, but again there is no clear evidence as to where the deficit is incurred.

Developed SIPER nations spend relatively less on consumption and investment and relatively more on defense. This is a reversal of the pattern found in our examination of the size attribute. Real nations, which are more developed, seem to follow a similar pattern of decreasing

TABLE 19

CORRELATIONS OF ATTRIBUTES AND ALLOCATION BEHAVIOR

BEHAVIOR		ATTRIBUTE								
		Size			Development			Accountability		
		Real	Siper	INS	Real	Siper	INS	Real	Siper	INS
Consumption	r	-.13	.26	-.39	-.38	-.73	-.18	-.02	-.18	.19
	Sig		.004	.04	.017	.0005			.05	
Investment	r	-.05	.44	.21	.21	-.17	-.06	.07	-.03	.25
	Sig		.0005			.072				
Defense Effort	r	.36	-.41	.08	.53	.74	.17	-.44	.22	-.46
	Sig	.026	.0005		.001	.0005		.005	.018	.015

Sample size

Real	41
Siper	120
INS	30

r = second order partial correlation coefficient of the behavior variable listed on the left with the attribute variable listed above, controlling for the effects of the other attribute variables, in the data source above.

Sig = significance level of the coefficient if less than or equal to .10 for the test of the null hypothesis that r = 0.

consumption's share of the national wealth and increasing the relative size of the defense sector. Developed INS nations, on the other hand, seem to act no differently than undeveloped nations with respect to the allocation of national wealth.

Finally, we find that more open SIPER nations tend to increase the defense share and decrease the consumption share as compared to less open nations. Real world and INS nations, however, decrease the relative size of the defense sector as their degree of accountability increases.

In seeking the source of these non-correspondences it will be useful to examine the inter-relationships between the three behavior variables in each of the three data sources. Figure 2 gives the simple correlations between consumption, investment, and defense for the referent and simulate worlds.[79] An examination of these triads shows clearly some basic patterns. In all three data sources the relationship between defense and investment is very weak. It appears that defense and investment are not commonly traded off in any of the worlds. This finding is somewhat

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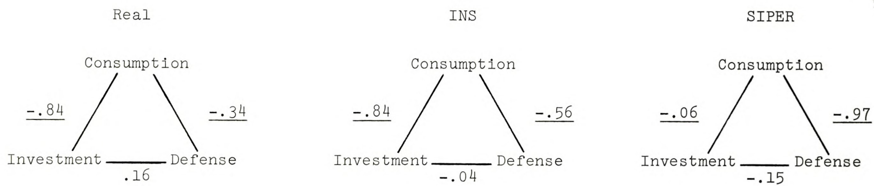
[79]Problems may arise when the variables being correlated have the same denominator, but as Kuh and Meyer state, "the question of spurious correlation quite obviously does not arise when the hypothesis to be tested has initially been formulated in terms of ratios..." Edwin Kuh and John R. Meyer, "Correlation and Regression Estimates When the Data are Ratios," Econometrica, Vol. 23 (October, 1955), pp. 400-416.

Figure 2

Simple Correlations Between

Consumption, Investment, and Defense



Correlations which are significant at the .05 level are underlined.

at variance with Russett's work.[80] He found that over time there was a tendency in the United States for increases in defense to be partially paid for by decreases in investment. The real world conclusions here are based on cross-sectional rather than longitudinal data, and Russett himself notes that the U.S. pattern is by no means cross-culturally constant. He finds that Canada, for example, exhibits the same behavior that we find above; there is a tendency for increases in defense to be paid for by decreasing consumption.[81]

Real world nations and SIPER nations provide quite a constrast with regard to the relationship of consumption to the other two sectors. As consumption declines real world nations seem to devote the released resources predominantly to investment, while SIPER nations devote the surplus to defense. It would appear that SIPER nations give national security a higher priority than economic growth and that, to some extent, the opposite is true in the real world. The pattern of INS trade-offs is clearly in between both SIPER and the real world. As consumption declines in INS nations, investment and defense increase, with the increases in defense being slightly better correlated to the decreases in consumption than increases in investment. The mixed nature of the INS pattern emerges clearly in a

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[80] Bruce M. Russett, "Who Pays for Defense?", American Political Science Review, Vol. LXIII, No. 2 (June, 1969), pp. 412-426.

[81] Ibid., p. 416.

statistical test of the significance of the differences between the correlations presented in Figure 2.

INS and SIPER do not differ in the degree of correlation of consumption and investment, but both are significantly different from the real world at the .01 level. On the other hand, INS and the real world do not differ significantly with respect to the correlation between consumption and defense, while both differ significantly, again at the .01 level, from SIPER. Clearly, INS has factors in common with both SIPER and the real world, while the latter are mirror images of one another.

A resetting of program parameters can remedy this non-correspondence. It will be recalled that a set of parameters discussed in section 6 of Chapter II, the budget crisis resolution weights PSPRI, EGPRI and NSPRI, establish the priorities of the expenditure sectors when conflict among goals is encountered. For this set of runs, an equal weight was given each sector. This means that the same proportion will be cut in each sector. By way of example let us consider a hypothetical case where a nation wants to allocate its resources in the following way.

Consumption	4/5ths of resources
Investment	1/5th of resources
Defense	1/5th of resources

This would, of course, be a crisis situation. Giving equal wieght to the sectors would reduce each sector by

one sixth.[82] The new allocations would be

Consumption	2/3rds of resources
Investment	1/6th of resources
Defense	1/6th of resrouces

Proportionately consumption has been cut as much as defense or investment, but in absolute terms, it has been cut four times as much as the other two sectors.

Since the overall mean percent levels of allocation are 84, 5, and 11 for the consumption, investment, and defense sectors respectively for SIPER nations, it is likely that _in the event of a budget crisis_ the type of reduction proposed above would take place. Such reductions would tend to produce the correlations found in the SIPER data.

Increasing the budget crisis resolution weight, PSPRI, of the consumption sector may enable us to replicate the real world pattern without further modification of the computer model. Further study is needed, however, and such study may suggest that a reformulation is necessary. It is interesting to note, however, that SIPER nations in one sense act as Bruce Russett suggests real world nations should act.

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[82] The desired level of expenditure is 4/5 + 1/5 + 1/5 = 6/5, and if each sector is given equal weight, the new value will be 5/6ths of its former value, or cut by 1/6th.

> It is bad to sacrifice future productivity and resources for current defense or war-fighting activities; insofar as possible such activities "should" be financed out of current consumption.[83]

Viewed from another perspective, however, the sacrificing of butter for guns may be an example of misplaced values.

8. National Attributes and Behavior: A Summary

One way of analyzing the overall validity of the computer model is to follow a practice we have used in previous sections. Defining a correspondence as existing when there is mutual confirmation of a positive, negative, or zero relation by the real world and a simulate source, we find that SIPER corresponds to the real world in 27 of the 42 relationships we have considered, and INS corresponds to the real world in 20 of these relationships. The breakdown is as follows:

	INS		
SIPER	Correspondence	Non-Correspondence	Total
Correspondence	14	13	27
Non-Correspondence	6	9	15
Total	20	22	42

SIPER is correct in just under two-thirds of the relationships while INS is correct in just under one-half. The occasions when SIPER is correct and INS is incorrect are better than twice as frequent as when SIPER is incorrect

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[83] *Ibid.*, p. 416.

and INS is correct. Furthermore, there appears to be a slight tendency for both models to produce non-correspondence when SIPER does not correspond to the real world. We think this evidence supports the contention that the SIPER model, although far from perfect, is superior to the Inter-Nation Simulation.

However, in order to facilitate independent overall evaluation of the simulations, we have prepared a table summarizing in a verbal and symbolic manner the relationships that we have found in the previous sections. Table 20 presents this information in the form of propositions that have found support in the analysis. A careful reading of this table should enable the reader to judge for himself the validity of the simulation with respect to its ability to replicate national behavior patterns.

Following each paragraph is a brief symbolic restatement of the relationships. S stands for size, D for development, and A for accountability, and the sign below each indicates the nature of the relationship that was found with respect to the dependent variable on the left.

TABLE 20

COMPARATIVE PROPOSITIONAL SUMMARY OF NATIONAL BEHAVIOR

Real Nations	SIPER Nations	INS Nations
Nations which experience more turmoil are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less turmoil.	Nations which experience more turmoil are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less turmoil.	Nations which are larger experience less turmoil than those which are smaller, regardless of their level of development or degree of accountability.
Turmoil — S D A: 0 0 0	Turmoil — S D A: 0 0 0	Turmoil — S D A: - 0 0
Nations which are more open experience less conspiracy than those which are less open, regardless of their size or level of development.	Nations which experience more conspiracy are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less conspiracy.	Nations which are larger experience less conspiracy than those which are smaller, regardless of their level of development or degree of accountability.
Conspiracy — S D A: 0 0 -	Conspiracy — S D A: 0 0 0	Conspiracy — S D A: - 0 0

TABLE 20--Continued

Real Nations		SIPER Nations		INS Nations	
Nations which experience more internal war are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less internal war.		Nations which experience more internal war are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less internal war.		Nations which experience more internal war are neither larger nor smaller, more developed nor less developed, more open nor less open than those which experience less internal war.	
	S D A		S D A		S D A
Internal War	0 0 0	Internal War	0 0 0	Internal War	0 0 0
Nations which are more open are more politically stable than those which are less open, regardless of their size or level of development.		Nations which are more open are less politically stable than those which are less open, regardless of their size or level of development.		Nations which are smaller and more open are less politically stable than those which are larger and less open, regardless of their level of development.	
	S D A		S D A		S D A
Stability	0 0 +	Stability	0 0 -	Stability	+ 0 -

TABLE 20--Continued

Real Nations	SIPER Nations	INS Nations
Nations which are more developed allocate relatively less to consumption than those which are less developed, regardless of their size or degree of accountability.	Nations which are larger, less developed, and less open allocate relatively more to consumption than those which are smaller, more developed, and more open.	Nations which are smaller allocate relatively more to consumption than those which are larger, regardless of their level of development or degree of accountability.
Consumption — S D A: 0 - 0	Consumption — S D A: + - -	Consumption — S D A: - 0 0
Nations which are larger and more developed grow more in absolute terms than those which are smaller and less developed, regardless of their degree of accountability.	Nations which are larger grow more in absolute terms than those which are smaller, regardless of their level of development or degree of accountability.	Nations which are more open grow more in absolute terms than those which are less open, regardless of their size or level of development.
Growth — S D A: + + 0	Growth — S D A: + 0 0	Growth — S D A: 0 0 +

TABLE 20--Continued

Real Nations	SIPER Nations	INS Nations
Nations which are larger and less developed have higher growth rates than those which are smaller and more developed, regardless of their degree of accountability.	Nations which are larger have higher growth rates than those which are smaller, regardless of their level of development or degree of accountability.	Nations which have higher growth rates are neither larger nor smaller, more developed nor less developed, more open nor less open than those which have lower growth rates.
Growth Rate — S D A: + - 0	Growth Rate — S D A: + 0 0	Growth Rate — S D A: 0 0 0
Nations which allocate relatively more to investment are neither larger nor smaller, more developed nor less developed, more open nor less open than those which allocate relatively less to investment.	Nations which are larger and less developed allocate relatively more to investment than those which are smaller and more developed, regardless of their degree of accountability.	Nations which allocate relatively more to investment are neither larger nor smaller, more developed nor less developed, more open nor less open than those which allocate relatively less to investment.
Investment — S D A: 0 0 0	Investment — S D A: + - 0	Investment — S D A: 0 0 0

TABLE 20--Continued

Real Nations	SIPER Nations	INS Nations
Nations which are larger, more developed and less open possess greater force capabilities than those which are smaller, less developed, and more open.	Nations which are larger and more developed possess greater force capabilities than those which are smaller and less developed, regardless of their degree of accountability.	Nations which are larger and more developed possess greater force capabilities than those which are smaller and less developed, regardless of their degree of accountability.
Force Capability — S D A: + + -	Force Capability — S D A: + + 0	Force Capability — S D A: + + 0
Nations which are larger, more developed, and less open allocate relatively more to defense than those which are smaller, less developed, and more open.	Nations which are smaller, more developed, and more open allocate relatively more to defense than those which are larger, less developed, and less open.	Nations which are less open allocate relatively more to defense than nations which are more open, regardless of their size or level of development.
Defense Effort — S D A: + + -	Defense Effort — S D A: - + +	Defense Effort — S D A: 0 0 -

TABLE 20--Continued

Real Nations	SIPER Nations	INS Nations
Nations which are larger, more developed and less open allocate more in absolute terms to defense than those which are smaller, less developed, and more open.	Nations which are larger, more developed and more open allocate more in absolute terms to defense than those which are smaller, less developed, and less open.	Nations which are larger and less open allocate more in absolute terms to defense than those which are smaller and more open, regardless of their level of development.
S D A Defense Spending + + -	S D A Defense Spending + + +	S D A Defense Spending + 0 -
Nations which are larger trade relatively less than those which are smaller, regardless of their level of development or degree of accountability.	Nations which are less developed trade relatively less than those which are more developed, regardless of their size or degree of accountability.	Nations which trade relatively less are neither larger nor smaller, more developed nor less developed, more open nor less open than those which trade relatively more.
S D A Relative Trade - 0 0	S D A Relative Trade 0 - 0	S D A Relative Trade 0 0 0

TABLE 20--Continued

Real Nations		SIPER Nations		INS Nations	
Nations which are larger and more developed trade more in absolute terms than those which are smaller and less developed, regardless of their degree of accountability.		Nations which are larger trade more in absolute terms than those which are smaller, regardless of their level of development or degree of accountability.		Nations which trade more in absolute terms are neither larger nor smaller, more developed nor less developed, more open nor less open than those which trade less in absolute terms.	
	S D A		S D A		S D A
Trade Magnitude	+ + 0	Trade Magnitude	+ 0 0	Trade Magnitude	0 0 0
Nations which are more developed engage in more diplomatic conflict than those which are less developed, regardless of their size or degree of accountability.		Nations which are more developed engage in more diplomatic conflict than those which are less developed, regardless of their size or degree of accountability.		Nations which are smaller and less open engage in more diplomatic conflict than those which are larger and more open, regardless of their level of development.	
	S D A		S D A		S D A
Diplomatic Conflict	0 + 0	Diplomatic Conflict	0 + 0	Diplomatic Conflict	- 0 -

CHAPTER V

STIMULATED INTERNATIONAL SYSTEMS

The intention of this chapter is to examine the international systems that have been produced by the SIPER computer simulation model and assess their validity. Before we can do this, however, we will find it necessary to state the limitations that we must place on this endeavor. Within these limits we then will state our correspondence criteria and the behavior measures which will be used in the analysis. We then will be able to proceed with the evaluation of the international systems produced by the computer simulation model in terms of their static and dynamic correspondence.

1. Comparing International Systems: Constraints and Limitations

The twenty-four international systems which were created using the different input configurations described in Chapter III will be treated here as independent entities. Ideally, we would want to compare each of these systems to the referent system and evaluate the inter-system correspondence. However, there are several reasons why the matter is not so simple as this.

We must recognize here, as we did in the previous chapter, the special validation problems confronted by

models that generate behavior for "prototypic" units. In that chapter we explained how the simulated nations were not designed to represent particular nations, but rather broad classes or genotypes of nations. Consequently, it follows that the simulated international systems we will consider here are not to be considered as necessarily models of any past or present international systems. Indeed, it is the purpose of this chapter to determine if there is any correspondence between the simulated international systems and past or present referent international systems.

It is perhaps unfortunate that we cannot state unequivocally that we sought in this series of computer runs to simulate the nineteenth century European system or the twentieth century bipolar world, but the preliminary nature of this research would suggest that selecting such an objective would be premature. International systems take shape through the interaction of the nations comprising the system, and until we have some knowledge as to the dynamic nature of the model we cannot be sure that our parameter settings and variable initializations will produce the desired system. Moreover, one of the purposes of the present research is to determine the kinds of international systems that result when various formulations prescribing the behavior of nations are drawn together in an interactive context.

In the previous chapter we were able to partially overcome the validation problem being discussed here by extracting "genotypic" nations by means of controlling statistically for major dimensions of inter-nation variability. With a large sample of nations it was permissible to talk of larger and smaller, more developed and less developed, and more open and less open national systems. That strategy is not available to us here, since we do not have a sufficiently large sample of international systems to allow us to proceed in a manner analagous to the one used in the previous chapter, and, accordingly, we must seek another way.

Paul Smoker has pointed out that just as a photographer must preset his camera to bring certain desired objects into clear focus, and consequently distort those objects which are closer to or farther from the camera than the desired object, so must the researcher select his focal point of analysis. It is a simple matter to concede that we cannot observe the totality of a complex system, but the decision as to what part of a complex system shall be observed is by no means a simple one.

The fundamental criterion to be employed in making such a decision is the end that such observation is to serve. In our case, the preliminary nature of the research suggests that we open the aperture of our analytical "camera" to its fullest extent and focus our attention on the grand structure and transformation of the simulated

international systems. Our observation will be superficial in the same way, and possibly to the same extent, that a wayward Michigan motorist would find an aeriel photograph of the state of Michigan superficial. Our purpose here is not to help wayward international relations scholars, but rather to find our own approximate location, and our correspondence mapping will reflect this objective.

Accordingly, we have had to conceptualize and measure the structure and transformation of international systems from a perspective that has rarely been taken in international relations research. The validation variables are macro-political-economic concepts, measuring fundamental systemic behavior. Any other kind of variable would be inappropriate to the task we have set out before us. In section 2 we will discuss these correspondence measures in some detail.

Another limitation that we face in the following analysis is the fact that it is neither feasible nor efficient to evaluate all twenty-four of the simulated international systems. We will, instead, select samples of systems to be subjected to analysis in sections 3 and 4 below. We will not seek random samples, however, but rather we will endeavor through the means of Q-factor analysis, to extract systems that are orthogonal to one another. This strategy should provide us with the variety of simulated international systems that is desirable.

To further simplify the analysis we have divided it into static and dynamic correspondence studies. The former refers to an observational perspective where the effects of time are removed, and the question is, "what are the basic structural properties of the system during the span of observational time?" Static analysis has been compared to the study of still photos, and the analogy seems appropriate here. Dynamic correspondence, on the other hand, poses questions concerning the direction and rate of system transformation. The emphasis here is on change rather than continuity, and it is felt that dynamic correspondence is a more exacting test of a model than static correspondence.

Section 5 is devoted to a discussion of the effects of the different parameter settings and variable initializations that were used to generate the twenty-four systems.

2. The Correspondence Criteria: Measures of Systemic Behavior

What features of international systems are especially salient for analysis? In a general systems sense, some of the most interesting questions involve how energy is utilized in a system. That is, to what ends and in what ways are the system's resources used? Physicists tell us that energy or work is required to organize nature into socially useful forms. It may be that precisely the same expenditure of energy is required to turn iron ore into a sword as it takes to turn the ore into a plowshare, but

from a social perspective there is a difference worth noting.

This difference is precisely where we seek to make our comparisons. We will assume that at any point in time there is a finite amount of social energy in a social system which may be used to produce socially useful forms.[1] The question that we will generally address ourselves to is, "how is this social energy apportioned out to the various spheres of activity which are available?"

In particular we will be interested in four major spheres of activity; system maintenance, system expansion, system defense, and system integration. It is an implicit measurement assumption in what follows that the relative allocation of social energy into one of these spheres of activity is reflected in the relative level of analogous economic activity in the system. This is not to assume that they are one and the same, but rather that the share of social energy devoted to a particular task can be measured by the share of scarce economic resources devoted to its accomplishment. It is obvious that these measures

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[1]For an interesting discussion of the concept of social energy see the following by George G. Lamb: "Engineering Concepts and the Behavioral Sciences," General Systems, XIII (1968), pp. 165-169; (Evanston, Ill.: Department of Chemical Engineering, Northwestern University, December, 1968); and "Basic Concepts in Subjective Information Theory, Thermodynamics and Cybernetics of Open Adaptive Societal Systems" (Evanston, Ill.: Department of Chemical Engineering, Northwestern University, August, 1969).

will enable us to estimate only the most aggregate kinds of activity, but such will serve our purposes.

System Maintenance Activity

System maintenance refers to that share of activity which performs the function of energizing and revitalizing the system.[2] This is the fundamental process by which systems apply energy to the task of sustaining and rebuilding structures. Existing systems, without system maintenance activity, tend to proceed toward an entropic state, and consequently, energy must be applied to the task of renewing the system. In comparing international systems we will want to examine the question, "what proportions of the various systems' resources are allocated to the performance of this function?"

To operationalize this variable we will turn to the field of macro-economics. Heilbroner tells us that the flow of consumption goods "is the vital process by which the population replenishes or increases its energies and ministers to its wants and needs, it is a process that, if halted very long, would cause a society to perish."[3] It follows, then, that we may use the proportion of total economic activity devoted to consumption, or consumption-

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[2] F. Kenneth Berrien, General and Social Systems (New Brunswick, N. J.: Rutgers University Press, 1968), pp. 25-26.

[3] Robert L. Heilbroner, Understanding Macro-Economics (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1968), p. 13.

product ratio, as an adequate measure of the relative system maintenance activity level for an international system. Because of the decentralized nature of international systems it is felt that this value can be best estimated by computing the inter-system value on the basis of the national system maintenance levels.

In the SIPER and INS international systems the estimates of system maintenance activity were derived in the following way. The proportion of the gross simulated product devoted to consumption was computed for each nation and period of time. The international system activity level was taken as the average of the national system levels in a particular period of time. An analogous estimation procedure was used for the referent data. Private consumption as a proportion of gross national product is used as the basic indicator, and international system levels are again estimated by taking the average of the activity levels of the nations comprising the system.

System Expansion Activity

System expansion activity refers to activity which performs the function of expanding the resource capability of the system. The growth of a system "is possible only if some storage of energies occurs with a system...".[4] Consequently, system expansion activity will be associated

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[4]Berrien, op. cit., p. 80.

with the investment of some portion of the system's output with the purpose of expanding future output.[5]

In the SIPER and INS international systems such activity may be measured by taking the average of the proportions that investment is of gross simulated product for the various nations in the system. In the referent system the relevant national values are gross capital formation as a proportion of gross national product, and the international system activity level is extracted by taking the average of these investment-product ratios.

System Defense Activity

System defense activity refers to that sphere of systemic activity which has as its objective the protection of the system against external and internal threats. Systems may expend substantial amounts of energy preparing for and waging conflicts, and the transformation of men and objects into means of destruction is a matter of high concern for national systems. Accordingly, we will want to examine the level of activity which is of this nature in the international systems under consideration.

In the SIPER and INS international systems the level of such activity is indicated by the average national defense allocation as a proportion of gross simulated

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[5]See Kenneth Boulding, "Toward a General Theory of Growth," The Canadian Journal of Economics and Political Science, XIX, 3 (August, 1953), pp. 326-340, for a general discussion of the growth phenomenon.

product. Similarly, the referent international system activity levels will be indexed by the average national defense expenditure expressed as a proportion of gross national product. These indices will be referred to as the defense-product ratios.

System Integration Activity

By system integration we mean the degree to which the units in a system are coupled in some cooperative manner. Units are coupled to the degree that the output of each serves as input to the other units, or, in other words, units which are coupled have reciprocal inputs.[6] Systems which have highly coupled units will have a high level of interdependency among the units, and in this sense may be considered highly integrated.

In the case of international systems we would consider them integrated to the degree that the national systems interact cooperatively. Here we will be particularly concerned about the degree to which the nations exchange goods and services. Accordingly, system integration activity will be operationally defined as the average national foreign trade ratio. In the SIPER and INS systems, this is the average national exports plus imports expressed as a proportion of gross simulated product. For the referent systems, system integration activity is the

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[6]Berrien, op. cit., pp. 59-69.

average national exports plus imports expressed as a proportion of gross national product.

By way of review let us restate the variables we will be using in the analysis. In the following formulations n is the number of nations in the international system.

System Maintenance Activity = Consumption-Product Ratio

$$= \frac{\sum_{i=1}^{n} \frac{\text{Consumption (i)}}{\text{National Product (i)}}}{n}$$

System Expansion Activity = Investment-Product Ratio

$$= \frac{\sum_{i=1}^{n} \frac{\text{Investment (i)}}{\text{National Product (i)}}}{n}$$

System Defense Activity = Defense-Product Ratio

$$= \frac{\sum_{i=1}^{n} \frac{\text{Defense (i)}}{\text{National Product (i)}}}{n}$$

System Integration Activity = Trade-Product Ratio

$$= \frac{\sum_{i=1}^{n} \frac{\text{Exports and Imports (i)}}{\text{National Product (i)}}}{n}$$

It is felt that this set of variables will enable us to make some insightful comparisons of simulated and referent international systems and draw some preliminary conclusions as to the validity of the former in relation to the latter.

3. System Structure and Static Correspondence

We will be concerned here with the structure of behavior within the various international systems, and the degree to which these structures are homomorphic. Before proceeding further, however, we must pause to select our sample of systems.

The Sample of Systems

As in Chapter IV, we want to examine three types of systems; the SIPER computer simulated systems, the INS man-machine simulated systems, and referent systems.

Our first task is to draw a sample of SIPER systems that is representative of the underlying dimensions of variation in the twenty-four systems. What we require is a set of variables that will allow us to measure the degree of similarity between systems. Table 21 indicates the variables that will be used for this purpose. It will be noted that the two lists resemble the variables used in the previous chapter. Our objective here is to measure the same phenomena at the international systems level, and consequently our measures are slightly different.

The variables listed on the left of Table 21 indicate the magnitude of the various kinds of phenomena in the international system. Those on the right measure the degree of dispersion in the distributions of these magnitudes over the nations in the systems--that is, the extent to which the nations are different from each other with respect to variables in the left hand column. The system

TABLE 21

SYSTEM STATE VARIABLES

Size Level	Size Dispersion
Development Level	Development Dispersion
Accountability Level	Accountability Dispersion
Turmoil Level	Turmoil Dispersion
Conspiracy Level	Conspiracy Dispersion
Internal War Level	Internal War Dispersion
Stability Level	Stability Dispersion
Consumption Level	Consumption Dispersion
Growth Level	Growth Dispersion
Growth Rate Level	Growth Rate Dispersion
Investment Level	Investment Dispersion
Force Capability Level	Force Capability Dispersion
Defense Effort Level	Defense Effort Dispersion
Defense Spending Level	Defense Spending Dispersion
Relative Trade Level	Relative Trade Dispersion
Trade Magnitude Level	Trade Magnitude Dispersion
Diplomatic Conflict Level	Diplomatic Conflict Dispersion

variables were given values in the following ways.

The level variables, those on the left of Table 21, were determined to be the average of the national levels. For example, if the sizes of nations making up a particular system were 10, 9, 8, 7, and 6 at some point in time, then the system state variable, size level, would be assigned a value of 8, the average of the national values, for that point in time. Since we have eight periods of simulated time to deal with, we will have seventeen measures of various kinds of activity in the international system and eight observations on each measure.

It is clear that these level measures only describe one aspect of the differences between systems that we want to take into consideration. Two systems may have the same size level but have radically different degrees of size

inequality. Accordingly, the variables on the right in Table 21 are designed to tap such differences. Of the measures of inequality available to us,[7] one that seems particularly useful to us here is the coefficient of variability.[8] This measure is defined as the standard deviation of a distribution divided by its mean, and has the characteristic that equality in the distribution is approached as the coefficient approaches zero.

The dispersion variables were assigned values equal to the coefficient of variability of the distribution of the various phenomena among the system's nations. Returning to the size example given above, the mean and standard deviation for that distribution of national sizes would be 8.0 and 1.414 respectively. The size dispersion variable for that point in time would be 1.414/8.0 or approximately 0.177. Eight time points give us eight observations on the seventeen dispersion variables, and these, in conjunction with the seventeen level variables, constitute the set of variables that describe each simulated international system across time.

In this part of our analysis we are interested in the structural aspects of the systems, and therefore we will want to concentrate our attention on the continuities of

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[7]See Hayward R. Alker, Jr., and Bruce M. Russett, "Indices for Comparing Inequality" in Richard L. Merritt and Stein Rokkan, eds., Comparing Nations (New Haven: Yale University Press, 1966), pp. 349-372.

[8]Hubert M. Blalock, Social Statistics (New York: McGraw-Hill, 1960), pp. 73-74.

systems. For each system we collapsed the time dimension by taking the average of each system state variable over time so that the profile of each system was contained in a set of 34 values. The result was a 34 measure by 24 system matrix, and, with one further modification, this matrix was Q-factor analyzed. Each of the 34 rows of the matrix was standardized using the row mean and standard deviation in order to avoid inflated correlation coefficients due to differences in the ranges of the variables. Unities were substituted in the diagonal, and the principal axis solution was rotated orthogonally using the Kiel-Wrigley criteria.[9]

The rotated factor matrix is given in Table 22, and the systems have been regrouped into "pure" and "mixed" systems. "Pure" systems are those whose highest loading is at least twice its next highest loading, and these systems are grouped in the upper portion of the table. "Mixed" systems do not satisfy the above criteria and are found in the bottom half of the table. Factor loadings have been multiplied by 100 and rounded, and those greater than 49 are enclosed in parentheses.

We see from the table that there are six basic types of systems that qualify as "pure" systems, and the six

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[9]The Kiel-Wrigley rotation criterion provides for the rotation of the principal axis solution until a factor is encountered on which fewer than k variables have their highest loading. K was set at 1.

TABLE 22

ROTATED FACTOR MATRIX OF

SIPER SYSTEMS

	ORTHOGONALLY ROTATED FACTORS							
SYSTEM	1	2	3	4	5	6	7	8
19	(-98)	-10	1	0	1	16	- 9	2
13	(-96)	-10	5	2	- 5	19	-14	3
7	(-92)	11	0	-29	21	8	2	0
1	(-90)	12	5	-34	20	6	3	- 1
2	(79)	-38	6	-24	-23	10	11	29
16	- 2	(-92)	4	-11	- 5	26	-21	8
23	15	(-90)	3	- 7	-23	25	15	0
12	-10	17	(91)	-32	- 2	7	9	- 7
24	-17	- 4	(86)	13	-40	19	-13	0
8	-16	-21	5	(-91)	-18	16	- 1	4
20	- 4	-13	14	- 4	(-95)	15	- 5	0
21	-36	-33	9	-10	- 5	(84)	-14	2
15	18	-35	27	6	-30	(81)	- 2	6
6	(59)	-13	(59)	- 2	- 1	18	13	48
10	(-68)	-10	4	(-69)	0	2	4	-13
14	(67)	-16	13	10	(-64)	12	2	24
17	(52)	(-53)	6	8	(-55)	2	28	21
5	(53)	-23	11	-32	-45	-13	(56)	6
11	15	(-69)	- 6	(-54)	9	14	41	- 8
3	12	(70)	23	9	(-64)	- 9	4	- 8
9	-30	-10	10	(-52)	25	(73)	11	0
22	(-53)	-43	22	-15	-32	35	-46	- 8
18	37	-19	(66)	22	-34	13	- 5	44
4	35	8	29	-41	(-75)	- 5	8	2
Per Cent Total Variance	29	16	11	11	15	10	4	3

dimensions that define these types account for 92 per cent of the total variance. We will select the highest loading system from each of the first six factors as our sample of systems. Hence, our sample of systems and the indentifiers to be used in the analysis will be:

System	Identifier
8	A
12	B
16	C
19	D
20	E
21	F

The INS systems that will be used in the analysis are six twelve-period runs of the Inter-Nation Simulation model conducted by John Raser and Wayman Crow at the Western Behavioral Sciences Institute in 1962. These runs, which were part of the WINSAFE II exercise, have been discussed in Chapter III.

The referent systems used here will generally be of two kinds. The world system encompasses, in theory, all of the nations on the globe, but in practice this system must be more limited because of data limitations. We have endeavored, however, to make the sample as large as possible.

The other referent systems that will be used here are essentially subsystems of the world system. For the most part we will rely on subsystems isolated by Bruce Russett.[10] When possible we will examine four systems:

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[10]Bruce M. Russett, International Regions and the International System (Chicago: Rand-McNally, 1967).

the western community, Eastern Europe, Latin America, and the Afro-Asian subsystem. In certain cases we will find the need to substitute another subsystem, the Middle East, for one of these, and at other times we will examine only one of the above subsystems. Our choices were guided by the availability of reliable data.

Contemporary Systems

This section of our analysis will be devoted to the consideration of the SIPER and INS international systems as they compare to referent systems which are drawn from the contemporary world. The referent systems to be studied here include the nations listed in Table 23. The system value for each variable was based on as large a sample of nations as could be assembled from existing data sources. The referent data for this part of the analysis are drawn, for the most part, from the World Handbook of Political and Social Indicators.[11]

Patterns of System Maintenance Activity

Figure 3 indicates the system maintenance activity found in the simulate and referent data. On the average,

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[11]Table 48, "Private Consumption as a Percentage of G.N.P.," Table 47, "Gross Domestic Capital Formation as a Percentage of G.N.P.," Table 23, "Expenditure on Defense as a Percentage of G.N.P.," and Table 46, "Foreign Trade (Exports and Imports) as a Percentage of G.N.P." in Bruce M. Russett, et al., World Handbook of Political and Social Indicators (New Haven: Yale University Press, 1964), were the source of data for the consumption, investment and defense and trade variables.

TABLE 23

CONTEMPORARY REFERENT SYSTEMS

Latin America (la)		
Paraguay	Peru	Dominican Republic
Haiti	Chile	Nicaragua
Argentina	Venezuala	Ecudor
Brazil	Bolivia	Cuba
Honduras	Guatemala	El Salvador
Columbia	Uruguay	Mexico
Costa Rica	Panama	Trinidad & Tobago
Jamaica		

Western Community (wc)		
Netherlands	Belgium	Denmark
Ireland	Norway	Switzerland
Finland	Austria	Sweden
Portugal	Cyprus	Canada
West Germany	United Kingdom	Greece
Italy	France	Spain
Turkey	United States	Iceland

Afro-Asian (aa)		
Taiwan	Laos	South Vietnam
Cambodia	South Korea	Burma
Indonesia	Pakistan	Libya
Morocco	China	Thailand
Camerroon	Malava	Ethiopia
India	Afghanistan	Somalia
Tunisia	Philippines	Sudan
Ceylon	Rhodesia-Nyasaland	South Africa
Kenya		Ghana
Nepal	Liberia	Tanganyka
	Nigeria	

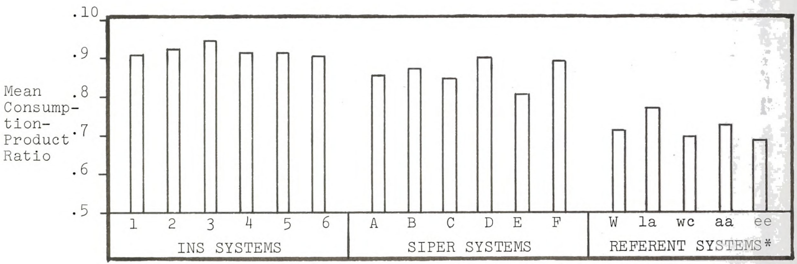
Eastern Europe (ee)		
East Germany	Bulgaria	Poland
Soviet Union	Hungary	

Middle East (me)		
Jordan	Iraq	Israel
Iran	Syria	Egypt
Lebanon		

World (w) - all of the above nations plus		
Yugoslavia	Australia	New Zealand

FIGURE 3

SYSTEM MAINTENANCE ACTIVITY



*See Table 23 for referent nations in each system.

INS systems devote 90 per cent of their economic activity to consumption, and all of the INS systems are within a narrow range of 89 per cent to 94 per cent. There is a good deal more variety in the consumption-product ratios in the SIPER systems; the minimum level is .80 and the maximum is .90. On the average, SIPER systems devote 85 per cent of their economic activity to consumption. The referent data presented in Figure 3 indicates the consumption-product ratio in the world system and four of its subsystems that were discussed previously.

It is clear that the correspondence of INS and SIPER to the referent systems is not great on this dimension. SIPER and INS systems differ only slightly with regard to system maintenance activity, and both types of systems are substantially more active than the referent systems in economic activity which serves to maintain the system. The closest correspondence seems to be SIPER system E and the Latin American subsystem. The respective consumption-product ratios are .80 and .75. Even here there is a significant gap between the simulated and referent systems. We observe that the simulated systems appear generally to be more like the less developed referent systems than the more developed referent systems. The referent systems which are most comparable to both INS and SIPER simulated systems are the Latin American and Afro-Asian subsystems. In a future section we will want to examine this relationship more fully.

Patterns of System Expansion Activity

Figure 4 presents the relevant data for the comparison of economic activity in the international systems which is of a system expanding nature. Again we are looking at the six INS systems, six SIPER systems, and the world system with four of its subsystems.

We find that the INS and SIPER systems are not substantially different in their investment-product ratios. The average investment level is about 7 per cent for the INS systems and about 5 per cent for the SIPER systems. In the contemporary world, by contrast, investment constitutes about 19 per cent of all economic activity. The referent subsystems are all substantially more active in this regard than any of the simulated systems. The correspondence is clearly not good here for either SIPER or INS, but we do find further evidence for the suggestion that the simulated systems are most like the Latin American and Afro-Asian subsystems.

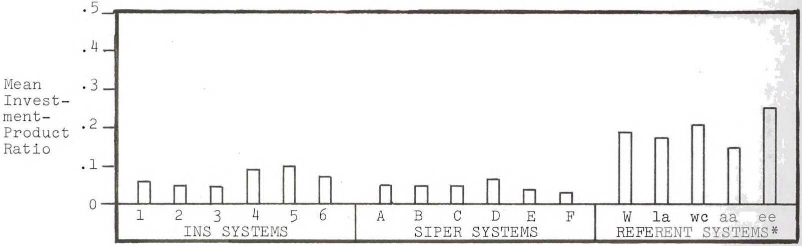
Patterns of System Defense Activity

Figure 5 presents the information with regard to the relative levels of system defense activity. Again we are examining six INS systems, six SIPER systems, the referent world system, and four of its subsystems.

On the average, INS systems channel about 4 per cent of their economic activity to the area of system defense, and this compares quite favorably with the referent world

FIGURE 4

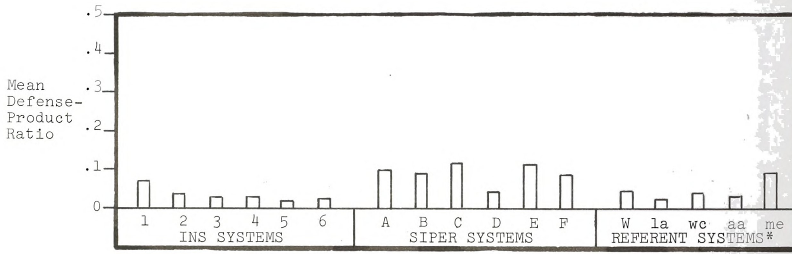
SYSTEM EXPANSION ACTIVITY



*See Table 23 for referent nations in each system.

FIGURE 5

SYSTEM DEFENSE ACTIVITY



*See Table 23 for referent nations in each system.

figure of about 3.9 per cent. In general, the correspondence of the INS systems in this sphere of activity is quite good.

The same cannot be said, however, with regard to the SIPER systems. Their average level of system defense activity is more than twice as high as that observed in the INS or referent systems. The average defense-product ratio for the SIPER systems is about .09, which compares favorably only to the Middle East subsystems. It seems evident that SIPER systems are highly militarized in general, but there are notable exceptions. System E, with a defense-product ratio of .04, is not substantially different from the referent world system. Nevertheless, it is clear that on the whole the correspondence of the SIPER systems to contemporary referent systems with respect to system defense activity is not good.

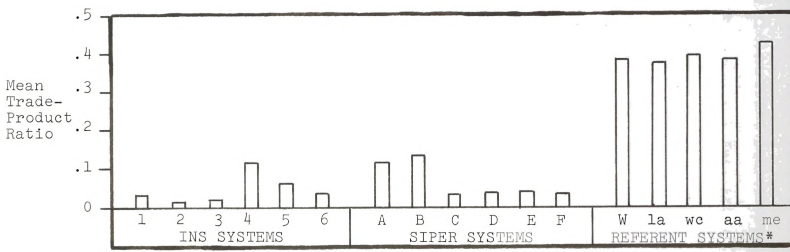
Patterns of System Integration Activity

Figure 6 gives the relevant information concerning system integration patterns in the INS, SIPER, and referent systems. In terms of economic activity, it is clear that the INS systems are characterized by a very low level of interaction among the components of the system. The average trade-product ratio is .045, the lowest system's ratio is .014 and the highest system's ratio is .114. This does not compare at all favorably with any of the patterns found in the referent data.

The SIPER systems are, on the average, about one and one-half times as active in system integration as the INS

FIGURE 6

SYSTEM INTEGRATION ACTIVITY



*See Table 23 for referent nations in each system.

systems are. The average trade-product ratio for the SIPER systems is about .071 with a low point of .03 and a high point of .14. These results compare a little more favorably with the referent indicators, but the correspondence is, on the whole, not very good. We are led to conclude that both kinds of simulated systems are considerably less active in system integration activity than the referent systems. As can be seen in Figure 6, there is very little difference between the referent subsystems. Our findings up to this point may be summarized thus:

1) Both SIPER and INS systems show a high level of system maintenance activity, in excess of what we observe in the contemporary world.
2) Both SIPER and INS systems show a very low level of system expansion activity, considerably below that which we observe in the referent systems.
3) SIPER systems exhibit a tendency towards excessive activity in the sphere of system defense as compared to referent systems, with the exception of the Middle East, to which they compare quite favorably. INS systems are not significantly unlike referent systems other than the Middle East in terms of their level of system defense activity.
4) Both SIPER and INS systems are characterized by a low level of system integration activity, as

compared with contemporary referent systems.

This set of observations suggests that the simulated systems do not compare favorably with the contemporary world. Let us turn our attention to the consideration of some past international systems.

Historical Systems

The strategy used here will be to select a subsystem of the international system and trace its development over time with respect to the four activity variables. The sample includes nations from Europe and North America: the United Kingdom, Germany, Italy, Norway, Sweden, the United States, Canada, Denmark and France, and it may be considered representative of the subsystem that we historically consider the West.

The information concerning patterns of system maintenance activity in the simulated and referent subsystem is given in Figure 7.[12] In this figure we have the average consumption-product ratios for the INS and SIPER systems as well as the consumption-product ratios for the referent subsystem at intervals of time. It would appear that the SIPER system consumption-product ratio compares favorably with that of the referent subsystem in the middle of the eighteenth century. At that time the referent subsystem was devoting approximately 82 per cent of its

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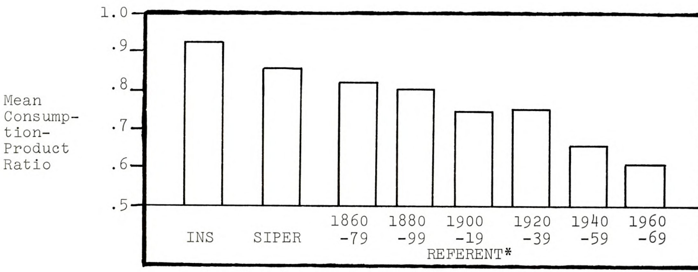
[12]The referent data is taken from Simon Kuznets, Modern Economic Growth (New Haven: Yale University Press, 1966), pp. 236-239.

FIGURE 7

PAST SYSTEM MAINTENANCE ACTIVITY



*Includes the following nations; United Kingdom, Germany, Italy, Norway, Sweden, United States, Canada.

economic activity to consumption. The SIPER consumption level, 85 per cent, is close to the referent level, and this may add validity to the hypothesis that the SIPER systems are pre-modern in nature. The INS systems represent a pattern of activity which exceeds the earliest period of referent data by about 10 per cent, and this may suggest that they pre-date the SIPER systems as well as the referent subsystem. However, it appears in general that the simulated systems, in terms of their system maintenance activity, are early or mid-nineteenth century western in nature.

Further evidence for the hypothesis that the simulated systems represent essentially pre-modern systems can be found in Figure 8.[13] Here we have the relevant information for system expansion activity for the INS, SIPER and referent subsystem. There appears to be a trend in the referent subsystem for the investment-product ratio to increase as one approaches the present. The investment-product ratio in the referent subsystem between 1860 and 1879 is approximately .14, considerably below the present day level of .23. Our data do not permit us to estimate the level of activity in the referent subsystem prior to 1860, but it seems likely that the level would approach

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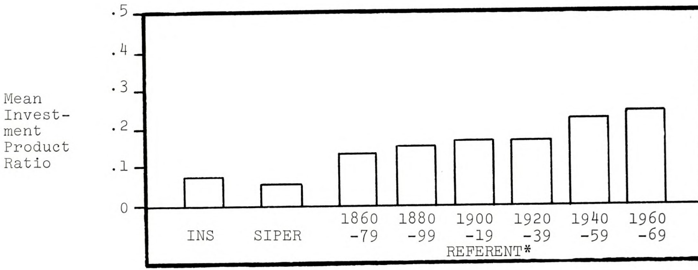
[13]Ibid.

FIGURE 8

PAST SYSTEM EXPANSION ACTIVITY



*Includes the United Kingdon, Germany, Italy, Norway, Sweden, the United States and Canada.

the SIPER and INS levels.[14] Again, the pre-modern system hypothesis is bolstered.

Figure 9 presents the comparative levels for system defense activity for the systems under consideration.[15] As one might expect, there is not such a clear trend in the referent data as with the other variables. The INS systems compare quite favorably in their level of system defense activity with the 1920 to 1939 pre-war period in the referent subsystem. SIPER systems, however, compare more favorably with the World War II and Cold War period of 1940 to 1959. Neither the INS nor the SIPER systems exhibit the kind of activity level that our data suggest characterized the nineteenth century referent subsystem. Rather than Pax Britannia we appear to have systems preparing for, or engaging in, major systemic conflict. If we may be permitted to speculate, it may be the case that the simulated systems are not unlike Napoleonic Europe. From what data we have, it might be inferred that system defense

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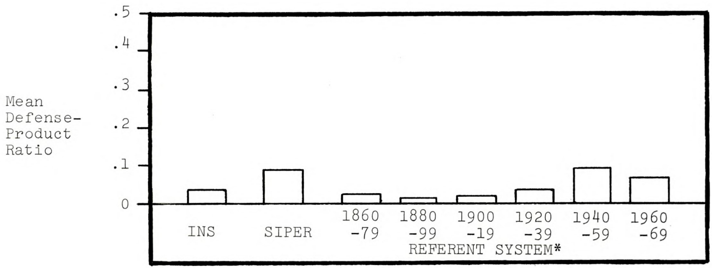
[14] See Simon Kuznets, "Quantitative Aspects of the Economic Growth of Nations: VI. Long-Term Trends in Capital Formation Proportions," Economic Development and Cultural Change, IX (July, 1961, Part II), for an extended discussion of investment in pre-modern and modern societies.

[15] The years 1870, 1890, 1929, 1948 and 1969 were selected as representative of the twenty year periods. The 1870, 1890 and 1929 data are from Quincy Wright, A Study of War (Chicago: University of Chicago Press, 2nd ed., 1965), pp. 666-672, and the 1948 and 1969 data are from Stockholm International Peace Research Institute, SIPRI Yearbook of World Armaments and Disarmaments, 1968/69 (New York: Humanities Press, 1970), pp. 194-214.

FIGURE 9

PAST SYSTEM DEFENSE ACTIVITY



*Includes the United Kingdom, Germany, Italy, France, Russia, and the United States.

activity levels were considerably higher in the Napoleonic period than in the last half of the nineteenth century. Some idea of the differences between these periods may be gained by examining data regarding the number of battles engaged in by the principal European nations in the eighteenth and nineteenth centuries. Figure 10 gives the data for 10 major powers by two decade periods.[16] The battle activity for the periods 1780 to 1789 and 1800 to 1819 are considerably higher than the earlier or later periods. Unfortunately we can only speculate as to whether system defense activity levels reached the levels recorded by the simulated systems during this period.

The final activity level we shall want to examine historically concerns system integration activity. Figure 11 presents the data concerning the level of this kind of activity for the simulated and referent systems.[17] As with our previous indicators we find a substantial change taking place over time in the referent subsystem. In the earliest period for which we have data, the trade-product ratio is about one third of current levels, and while still higher

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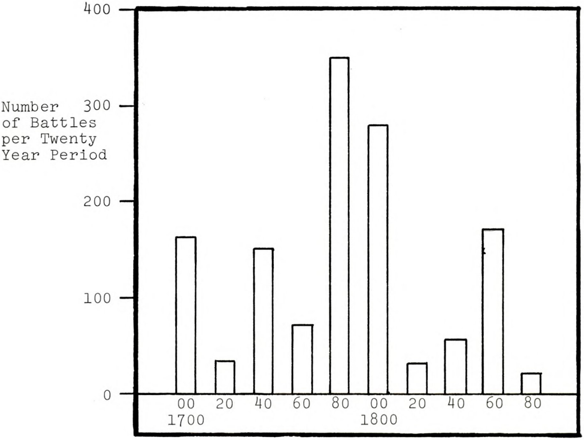
[16]Wright, op. cit., p. 692.

[17]The pre-twentieth century data were drawn from Kuznets, op. cit., p. 310-316. The years 1913, 1928, and 1957 and 1966 were chosen to represent the twenty year periods after 1900 and these data are taken from Karl W. Deutsch and Alexander Eckstein, "National Industrialization and the Declining Share of the International Economic Sector, 1890-1959," World Politics, XIII, 2 (January, 1961), p. 275 and United Nations Statistical Office, Statistical Yearbook, 1967 (New York: United Nations Publications, 1967).

FIGURE 10

NUMBER OF BATTLES INVOLVING

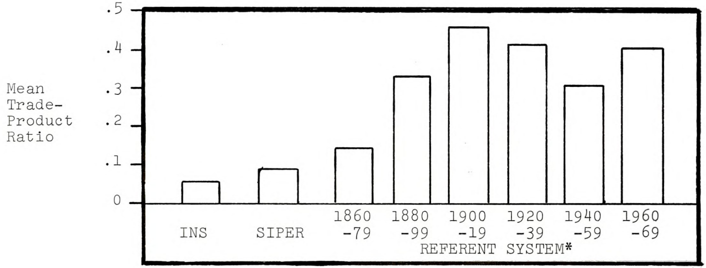
MAJOR EUROPEAN POWERS, 1700-1899



Twenty year periods denoted by first year.

FIGURE 11

PAST SYSTEM INTEGRATION ACTIVITY



*Includes the United States, the United Kingdom, Germany, France, Italy, Sweden, Denmark, and Norway.

than the levels found in the simulated systems, the comparisons are much more favorable. The tendency for preindustrial international systems to engage in this form of integrative activity, international exchange, relatively infrequently has been documented elsewhere.[18] We can, at this point, say that this finding is consistent with our previous ones concerning the pre-modern nature of the simulated systems.

On the basis of the evidence gathered concerning four areas of systemic activity, we have suggested that the simulated systems, both INS and SIPER, resemble in certain fundamental respects early nineteenth century Europe and North America; i.e., the western world. Our conclusion is based on the projection of trends backward through time due to the fact that our data only extend back one hundred years. Nevertheless, we suggest that the evidence is sufficiently convincing to warrant the conclusions we have drawn.

We have to this point emphasized the continuity of international systems by limiting our analysis to behavioral structures. In the next section we will turn to the consideration of the rate and direction of system transformation.

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[18] Simon Kuznets, "Quantitative Aspects of Economic Growth of Nations: X. Level and Structure of Foreign Trade: Long-Term Trends," Economic Development and Cultural Change, XIII (July, 1965, Part II).

4. System Transformation and Dynamic Correspondence

Dynamic correspondence exists between two systems to the degree that the two systems are undergoing similar transformations. For our purposes there are two aspects of the transformation process that are particularly salient. These are the direction of systemic change, e.g., are the systems becoming more or less militarized? and the rate of systemic change, e.g., how rapidly are the systems becoming more or less militarized?

We will again use our four measures of systemic behavior introduced in the previous sections to assess the dynamic correspondence of the simulated systems to the referent systems.

The Sample of Systems

In this section we will confine our attention to the SIPER and referent systems. INS systems do not lend themselves to the kind of analysis being undertaken here due to the irregularity of behavior. Rates and direction of change are very erratic and, consequently, no clear conclusions may be drawn from the INS data with regard to the transformation of systems.[19] If the central focus of this research were the validity of INS systems we would wish to pursue this point further, but since this is not

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[19]Regressing various INS behavior variables on time yielded very large standard errors for the regression coefficients. The standard deviation of the rates of change were also very large, indicating the absence of any simple linear trends. To this degree behavior is erratic.

the case we will simply omit the consideration of the INS systems from this part of the analysis.

To select a sample of SIPER systems we will return to a set of data previously discussed. In Section 3 of this chapter the creation of a set of system state variables was discussed, and it will profit us here to reuse these data in a different fashion.

It will be recalled that system values for the factor analysis were computed by averaging each variable over time. Our interest then was in the continuities in systems rather than the changes in them. Here we will use the average rates of change over the eight time periods for each of the 34 variables listed in Table 21 as our summary measures of systemic change. Again we have a 34 measure by 24 system matrix to be Q-factor analyzed. The principal axis solution was orthogonally rotated using the Kiel-Wrigley criterion, and the results are given in Table 24.

Again the order of the systems has been changed to illustrate the clusters that emerged from the analysis. Those systems for which the highest factor loading is at least twice the next highest factor loading have again been set off as "pure" and are grouped in the upper portion of the table. Those which do not meet this criterion are considered "mixed" systems and are grouped in the lower portion of the table.

Following the practice established in the previous section we will use one system from each factor and the

TABLE 24

ROTATED FACTOR MATRIX OF

CHANGING SYSTEMS

	ORTHOGONALLY ROTATED FACTORS					
SYSTEM	1	2	3	4	5	6
11	(-96)	-18	- 8	-12	- 6	- 7
10	(-94)	4	- 1	-23	- 8	12
15	(-91)	- 2	-18	6	- 6	30
9	(-89)	-34	-18	- 7	- 3	-21
20	(-88)	-26	-33	-14	- 8	- 4
3	(88)	19	38	15	10	7
21	(-86)	-33	26	-13	- 5	-22
6	(-84)	1	-22	19	- 1	45
17	16	(-93)	10	25	7	15
22	-32	(-92)	- 1	12	- 4	- 9
24	-28	(-92)	0	18	6	-13
12	-37	(-90)	-18	8	- 2	0
5	25	11	(93)	7	12	- 2
8	11	23	(92)	-13	4	- 1
13	-13	19	1	(-97)	0	- 3
7	18	30	1	(-93)	- 9	0
1	-43	4	0	(-89)	9	- 4
19	10	- 1	14	0	(98)	0
18	(-84)	-46	14	- 8	6	-16
2	(-72)	(-64)	-24	- 1	- 2	- 5
4	(-71)	(-56)	- 7	29	8	- 4
23	(-62)	(-73)	-28	4	- 4	1
16	(-64)	-30	(64)	- 8	- 6	-21
14	46	-47	(62)	23	25	11
Per Cent Total Variance	41	24	13	13	5	3

system which loads highest on a factor will be used to represent that factor. Our sample will be made up of the following simulated systems.

System	Identifier
5	A
11	B
13	C
17	D
19	E

In this section we will use only one of the subsystems delineated in Table 23. The availability of reliable data limits us to the consideration of the western community subsystem. In the short-term comparisons below, our system estimates will be based on the following sample of nations.

Austria	Greece	Portugal
Belgium	Iceland	Spain
Canada	Ireland	Sweden*
Denmark*	Italy*	Switzerland
Finland	Luxembourg	Turkey
France*	Netherlands	United Kingdom*
West Germany*	Norway*	United States*

The estimates of system activity used in the long-term comparisons are made on the basis of the sub-sample of nations whose names are followed by an asterisk.

Short-Term Comparisons: Contemporary Systems

This section and the two following it will endeavor to assess the dynamic correspondence of the simulated

systems to the subsystem of nations listed above.[20] As we have stated before, we will want to examine the direction and rate of change or transformation in the simulated and referent systems. In comparing rates of change some assumption as to the time scale to be used in relating the systems to one another must be made. That is, we must state that x units of simulated time are equal to X units of real time.

In this section we will assume that one period of simulated time is approximately one year of real time, and we will examine ten years of referent time. The behavior to be considered here includes the four system activity variables discussed earlier.

Changes in System Maintenance Activity

Figure 12 gives the rates of change, expressed in per cents, in consumption product ratios for the five SIPER systems and the referent subsystem for the years 1957 to 1966. The simulated systems vary considerably in their change rates, but all are in agreement with the referent subsystem that system maintenance is receiving a declining

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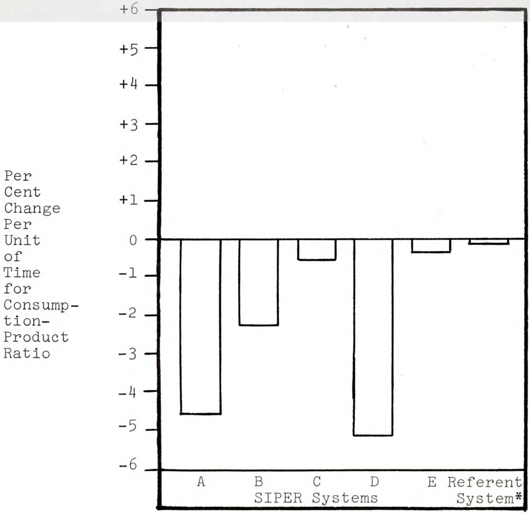
[20]The referent rates of change were estimated from 1957 to the 1966 consumption, investment and trade and gross national product data contained in the 1958 to 1967 editions of United Nations Statistical Office, Statistical Yearbook (New York: United Nations Publications). The table, "Expenditure vs. Gross National Product" was the source in each volume. The defense expenditure data for the source years came from Stockholm International Peace Research Institute, loc. cit.

FIGURE 12

CHANGES IN SYSTEM MAINTENANCE ACTIVITY:
CONTEMPORARY TRENDS



*Includes all nations listed on page 195.

share of economic resources. The decline in the simulated systems is considerably more rapid than in the referent subsystem, however. Expressed in half-life terms,[21] the level of system maintenance activity in the average SIPER system is reduced by one-half every 40.7 "years," while the comparable figure for the referent subsystem is 1,166.7 years. Comparatively speaking, system maintenance activity as indicated by the consumption-product ratio, is declining very rapidly in the simulated systems, and their correspondence to the relatively stable referent subsystem is not good.

Changes in System Expansion Activity

Figure 13 presents the data for comparing the changes that take place in the simulated and referent systems with regard to system expansion activity.

Again we find a good deal of variability in the rates of change in the simulated systems and unanimity with regard to the direction of change. The simulated systems vary from a low of 1.17 per cent decline per "year" to a high of 12.03 per cent decline per "year." This compares rather poorly with the 0.96 per cent per year increase in the investment-product ratio of the referent subsystem. At this rate, the investment-product ratio of the referent subsystem would double in about 73 years, while the ratio

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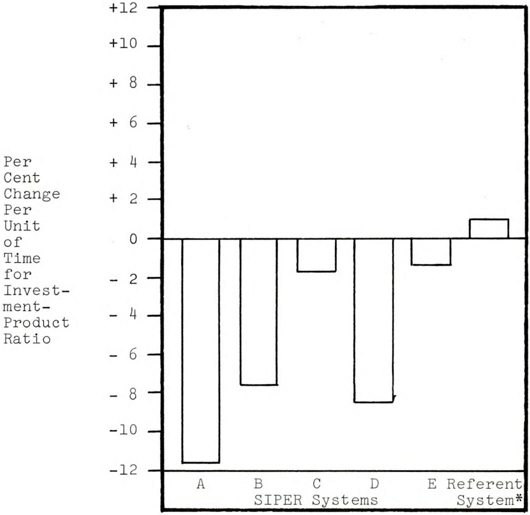
[21]Richard W. Chadwick and Karl W. Deutsch, "Doubling Time and Half-Life," Comparative Political Studies, I,1 (April, 1968), pp. 139-145.

FIGURE 13

CHANGES IN SYSTEM EXPANSION ACTIVITY:

CONTEMPORARY TRENDS



*Includes all nations listed on page 195.

of the simulated systems, on the average, would have been reduced by a factor of one-half some six times in a corresponding period of simulated time. Not even the best of the SIPER systems, system E, compares very favorably with the contemporary referent subsystem, and these results must give us pause for thought.

Changes in System Defense Activity

The rates of change with regard to system defense activity for the various systems under consideration are given in Figure 14. The simulated systems are devoting an increasing share of their resources to system defense, and these increases in some systems are of alarming proportions. System A, for example, exhibits a doubling of the proportion of resources going to defense approximately every 2.2 "years."

Contrast these rates with the decline of 1.88 per cent per year in the referent subsystem's defense-product ratio. Clearly, the dynamic nature of the referent subsystem has not been replicated in the simulated systems.

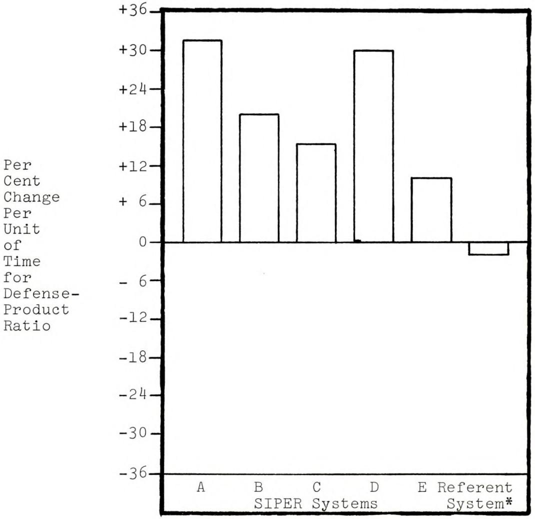
Changes in System Integration Activity

System integration activity, as can be seen in Figure 15, is of declining importance in the five simulated systems presented there. It should be noted, however, that these five systems are apparently not representative of the full variety of simulated systems, in this regard, since the average rate of change in the trade-product ratios for all

FIGURE 14

CHANGES IN SYSTEM DEFENSE ACTIVITY:

CONTEMPORARY TRENDS

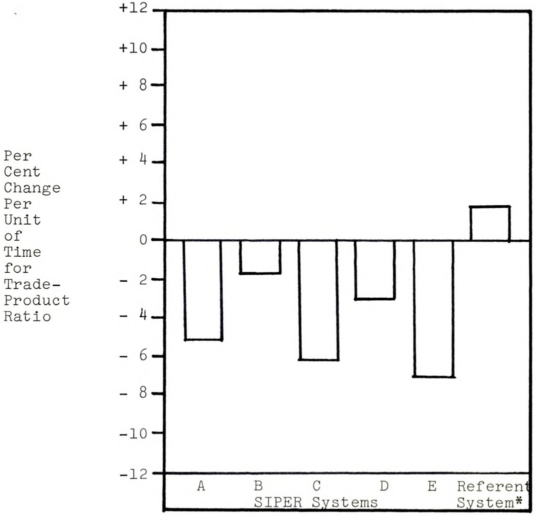


Includes all nations listed on page 195.

FIGURE 15

CHANGES IN SYSTEM INTEGRATION ACTIVITY:

CONTEMPORARY TRENDS



*Includes all nations listed on page 195.

twenty-four of the systems is an increase of 0.91 per cent per "year," rather than a decrease.

This latter figure compares much more favorably with the referent subsystem increase of 1.87 per cent per year than any of the simulated systems in our sample. These results are somewhat difficult to interpret, and perhaps it would be best to merely state that they are neither satisfactory nor entirely unsatisfactory.

Let us summarize our findings to this point.

1) System maintenance activity is declining substantially faster in the simulated systems than in the referent subsystem.

2) System expansion activity is declining significantly in the simulated systems in contrast to the slow increase in the referent subsystem.

3) System defense activity is increasing quite rapidly in the simulated systems as opposed to the slow decline in the referent subsystem.

4) System integration activity is declining in some simulated systems, but on the whole, there appears to be a tendency for such activity to grow slowly, as it does in the referent subsystem.

Applying a time scale where one period equals one year indicates that the magnitude of change in the simulated systems is much greater than that which has characterized the referent subsystem in recent years. During the years spanned by the data, 1957 to 1966, the referent subsystem,

as a whole, experienced declining tensions and increasing prosperity, and this relaxation is the reverse of the pattern found in the simulated systems.

We have two avenues of analysis open to us at this point. The first entails examining referent materials drawn from a system undergoing rapid change. The next section is devoted to this in an effort to reconcile the differences in the magnitude of change by, in effect, increasing the rate of change in the referent subsystem.

Another way of raising the magnitude of change in the referent subsystem is to alter the time scale. A later section will be devoted to this.

Short-term Comparisons: Extraordinary Periods

In the previous section we suggested that the simulated systems appear, by contemporary standards, to be systems under stress. We will pursue this observation further here. Since the data to be presented are drawn from a single national system rather than a sample of systems, the material which follows should be considered more illustrative than conclusive. We will consider the changes in the system activity levels in the United States during the years 1929 to 1933 and the years 1939 to 1943.[22] These five year spans

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[22]The consumption, investment, defense and trade data used in this section were taken from U. S., 1963-69, President (Johnson), Economic Report of the President, January, 1967 (Washington, D. C.: United States Government Printing Office, 1967), pp. 214-215, p. 221.

of time correspond, of course, with the onset of the great depression and the outbreak of World War II. These two periods were extraordinary in the history of the United States in as the magnitude of social change over a short period of time was inordinately great.

Extraordinary Period I: Severe Depression

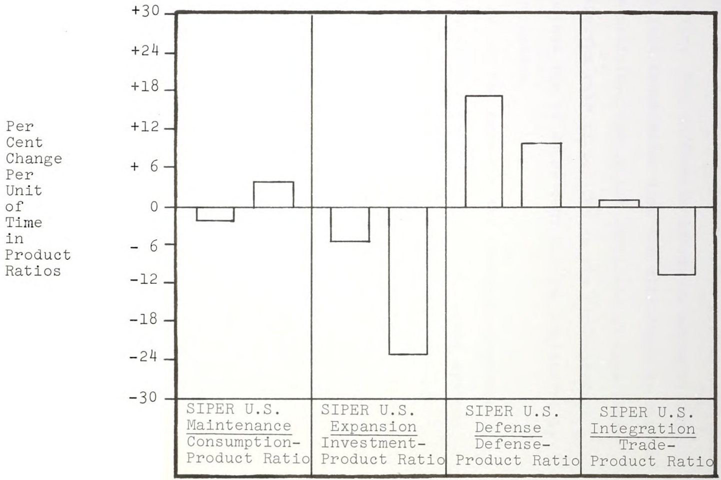
The great crash of 1929 opened a period of American history which witnessed severe economic dislocations. The rates of change in our four system activity variables given in Figure 16 reflect a small but significant aspect of that change.

During this period the share of resources devoted to consumption increased by about 4 per cent per year, while investment declined by some 23 per cent per year. At this rate of decline the investment-product ratio was reduced by one-half every three years.

System defense activity, by contrast, was increasing, relatively speaking. At a rate of about 10 per cent per year, the defense-product ratio could be expected to double in seven years. System integration activity, as indicated by the trade-product ratio, was declining at a similar rate, 10.4 per cent per year. Of course, the absolute values of each of the phenomena above were declining during this period, and the increases registered reveal that not all system activity levels are cut equally in a period of declining activity.

FIGURE 16

CHANGES IN SYSTEM ACTIVITY: SEVERE DEPRESSION



For comparative purposes we have included the average rates of change for all 24 SIPER systems with regard to system activity in Figure 16. There is agreement between the systems with regard to the direction of change for system expansion and defense, but not for system maintenance and integration. The difference in system integration activity is less troublesome than the difference in system maintenance activity. It is not difficult to cite SIPER systems where the rate of decline in the trade-product ratio approaches the 10.4 per cent decline registered by the referent system.

Such is not the case for the consumption-product ratio. The decline registered in the simulated systems does not match the increase observed in the referent system, and if this trend is characteristic of economically depressed systems generally, then it would appear that the simulated systems are not depressed. Moreover, the magnitudes of change in expansion and defense activity seem to be reversed for the two kinds of systems even though there is agreement in direction. Simulated system investment declines about 6 per cent per "year," while referent system defense activity increases by about 10 per cent per year, and referent system investment declines about 23 per cent per year while simulated system defense activity increases about 18 per cent per "year." Comparing strictly these magnitudes of social change, and not the directions of such change, we are led to conclude that the social changes

occuring in these systems are quite different. In the referent system rapid economic deterioration is taking place, and the speed of this deterioration is only matched by the rate at which the simulated systems are becoming militarized. Consequently, we have further reason to suspect that the simulated systems are not experiencing the stresses and strains associated with the phenomena of severe depression. Let us turn, then, to the consideration of a major war and the stress it imposes on a system.

Extraordinary Period II: Major War

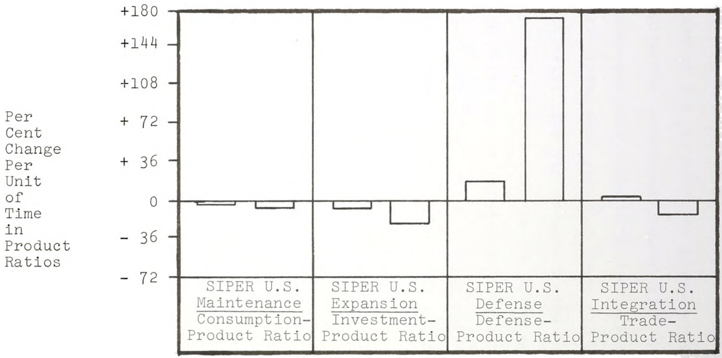
The span of years, 1939 to 1943, marked the United States' preparation for, and entry into, the Second World War. The data pertaining to the changes in system activity during this period are included in Figure 17. Again we have included the average rates of change for all twenty-four SIPER systems.

It will be noted that there is agreement between the systems as to the direction of change in three of the four categories of activity. In both SIPER and the referent national system,consumption and investment ratios are declining and the defense-product ratio is increasing. We find disagreement with regard to the direction of change in the trade-product ratios in the two kinds of systems, but a review of the SIPER systems in Figure 15 indicates that this difference between the two kinds of systems is not serious. A substantial number of the SIPER systems

FIGURE 17

CHANGES IN SYSTEM ACTIVITY:

MAJOR WAR



agree with the referent trend towards a decline in integration activity.

With respect to the other activities we find substantial agreement concerning the direction of change. In the process of gearing for war, the consumption-product ratio dropped by an average of 7.2 per cent per year over the five year period while the investment-product ratio dropped by about 22.9 per cent per year. The declines registered by the average SIPER system were somewhat less, 1.7 and 5.8 per cent respectively. The differences in the magnitude of change in the systems is best seen in the defense-product ratios. The average SIPER system expands defense activity by about 17.5 per cent per "year" while defense activity in the United States between 1939 and 1943 grew at the phenomenal rate of 171.8 per cent per year.

In each of the three cases the rate of change in the referent system is considerably greater than in the simulated system. Part of this difference can be reconciled by changing the time scale. If we assume that one simulation period equals three months of real time, then the yearly rates of change for the SIPER systems would be equal to the period rates raised to the fourth power. These rates are:

Activity	SIPER	United States
Maintenance	- 6.7	- 7.2
Expansion	-21.4	-21.6
Defense	90.0	171.8

The fit of maintenance and expansion activity is about as good as one can expect from complex models of this nature, but the difference remaining between the two rates of change in defense activity is still very great. Therefore, although it appears that the SIPER systems in general replicate the pattern of a system preparing for war, it does not appear that the militarization in any way compares with the experience of the United States in the early part of World War II.

We have examined periods of time when social change was extremely rapid. This perspective was dictated by the relatively rapid change occuring in the simulated systems. The other alternative available to us is to change the time scale so that one period of simulated time is equal to more than one year of real time. In the next section we will do precisely that.

Long-term Comparisons: Historical Systems

Whereas before we postulated that one period of simulated time equaled one year of real time, here we will assume that one period equals ten years of real time. In the past 100 years of western history, the western subsystem has been transformed in many ways, and we will compare the transformation of the SIPER systems to that which the West has undergone. The analysis will be conducted using the, by now, familiar activity variables.

Figure 18, gives the relevant information concerning transformation in these two kinds of systems.[23] The consumption-product ratio is decreasing in both systems, while defense and the international sector are absorbing larger shares of economic resources. This agreement does not hold with respect to the investment-product ratios. Investment is decreasing in the SIPER system and increasing in the referent system.

The differences between the rates of change in the two systems are not distrubing. Consumption drops by 1.7 per cent and 2.6 per cent in the SIPER and referent systems respectively, and defense increases by 17.5 per cent and 22.9 per cent respectively. The trade-product ratio is growing at a rate of 1 per cent in the SIPER systems, on the average, and the comparable figure for the referent subsystem is about 4 per cent. Returning to the consideration of expansion activity, we note that the investment-product ratio is declining by 6 per cent per "decade" in the average SIPER system and increasing by 6 per cent per decade in the referent subsystem. How is this difference to be explained?

The explanation, we believe, is as follows. Consumption is not falling fast enough to release the resources needed by investment and defense. The rate of decrease in

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[23]The referent rates of change were estimated using the data presented in Figures 5.5, 5.6, 5.7 and 5.9.

FIGURE 18

CHANGES IN SYSTEM ACTIVITY:

CENTENARY TRENDS

1. Sample includes nations listed in Figure 7.
2. Sample includes nations listed in Figure 8.
3. Sample includes nations listed in Figure 9.
4. Sample includes nations listed in Figure 11.

the consumption-product ratio, 1.7 per cent, is not sufficient to offset the rate of increase in the defense-product ratio, 17.5 per cent. Consequently, the remaining defense needs are filled out with resources that previously were channeled into expansion activity. The result is a decline of 5.8 per cent in the investment-product ratio.

This situation is further aggravated by, and, in part, a consequence of, the differences between the system activity levels in the 1860 referent subsystem and the beginning activity levels for the SIPER runs. As we learned in Chapter III, the SIPER systems begin life with some initial values for the variables that we have based our system activity measures on. In the language of this chapter, the average SIPER system begins life with the following activity levels.

Maintenance	-	91.0 per cent
Expansion	-	5.6 per cent
Defense	-	3.4 per cent

The initial consumption-product ratio of .91 is considerably above the referent system's .82, which we estimated to hold in 1860. The investment-product ratio, by contrast, is too low initially. This ratio is initialized at .056 when the comparable 1860 referent value is something like .14. Finally, the defense-product ratio is too high. The initial value for the simulated systems is roughly twice that of the referent subsystem of the 1860's.

System maintenance activity at the outset occupies too many of the system's resources as compared to the

western world of the 1860's. This fact was pointed out earlier in this chapter. Expansion activity is too low by the standards of 1860, and defense activity is too high. Our conclusion is that the simulated systems begin life with activity patterns as might have characterized the western world around 1800, a less industrialized and more militarized period. However, they do not experience the comparatively mild nineteenth century militarization, but rather they are engulfed in an escalation of armaments more appropriate to the twentieth century.

If we could be allowed to speculate once more, we might postulate that the relatively mild militarization of the nineteenth century might not have been so mild if France had not been defeated early in the century and/or the Concert of Europe had been less successful in executing the role Rosecrance calls regulator.[24] The period which we contend best fits the starting conditions of the SIPER runs, which Rosecrance calls the "revolutionary imperium," (1789-1814) is of particular interest to us in one respect. "The outcomes which emerged from the interaction of regulative and disruptive elements assumed the form of a bipolar international system. In both territorial and ideological terms the improvement in the position of one bloc would automatically involve the worsening in the position of the

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[24] Richard Rosecrance, Action and Reaction in World Politics (New York: Little, Brown, 1963), pp. 220-232.

other."[25] It will be recalled that the simulated systems were bipolar in their structure throughout their duration. In Europe, however, the defeat of France marked the disappearance of the bipolar structure for over half a century. When it re-emerged, a militarization of the system took place which bears a striking resemblance to the transformations we observed in the SIPER systems. Taking our speculation further, we might propose that we have simulated an alternative past with the nineteenth century nations organized in a bipolar rather than a balance of power configuration, a past, incidentally which looks considerably less inviting than what actually took place.

5. The Effects of Parameter and Variable Settings

We will consider here the specific ways in which the parameter and variable settings account for the differences between systems that we have observed. Table 25 presents the basic data for the consumption, investment, defense and trade variables we used in the previous sections. Both the mean levels of activity and the mean rates of change are given for each system. We shall first consider the effects of parameter variation.

In Chapter III we indicated how the parameters were varied for the twenty-four systems. Systems 1 through 6 were set up to operate with the pragmatic information processing rule, Rule 0, and with unbiased export prices.

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[25] _Ibid._, p. 239.

TABLE 25

BASIC SIMULATED SYSTEM DATA

	VARIABLE							
SYSTEM	1	2	3	4	5	6	7	8
1	89.5	5.7	4.8	10.6	-0.6	-1.8	16.5	1.5
2	79.3	4.2	16.8	10.0	-2.1	-10.4	21.8	-7.2
3	84.3	3.7	12.4	10.2	-2.4	-8.5	20.8	2.7
4	83.1	5.0	12.1	9.9	-2.2	-6.0	20.2	-3.8
5	80.2	4.3	15.9	10.4	-4.7	-12.0	31.4	-5.2
6	78.2	3.8	18.4	10.3	-2.9	-16.8	26.5	-12.4
7	90.5	5.8	3.6	10.2	-0.3	-1.2	9.4	0.2
8	85.1	5.1	10.2	11.6	-1.0	-3.2	11.3	-0.2
9	87.5	4.0	8.7	10.6	-0.7	-2.5	9.0	1.4
10	88.0	5.5	6.6	11.1	-0.4	-1.5	7.7	1.3
11	82.9	4.7	12.8	10.3	-2.3	-7.4	19.9	-1.9
12	86.7	4.9	9.2	13.0	-1.0	-5.5	15.6	6.5
13	89.9	5.5	4.6	3.4	-0.5	-1.7	15.2	-5.8
14	79.3	4.1	16.8	4.2	-2.0	-10.4	22.0	-0.6
15	84.9	3.7	11.5	3.6	-2.1	-6.6	19.7	7.1
16	84.0	4.9	11.3	3.0	-1.5	-5.8	16.9	15.5
17	78.0	4.3	17.7	4.1	-5.1	-8.5	30.0	-3.1
18	79.3	4.3	16.5	3.6	-3.3	-9.9	29.5	5.6
19	90.7	5.6	3.7	3.3	-0.3	-1.2	9.7	-7.1
20	84.5	4.8	10.7	4.4	-1.1	-4.3	12.3	1.8
21	87.8	3.9	8.2	3.8	-0.4	-2.6	7.1	0.7
22	87.8	5.4	6.9	1.9	-0.7	-2.6	10.6	17.5
23	81.7	4.6	13.7	4.2	-2.6	-5.5	20.7	1.5
24	85.8	5.0	9.3	3.7	-1.1	-4.0	15.5	5.7

VARIABLE CODE

1. Average consumption as a per cent of gross simulated product.
2. Average investment as a per cent of gross simulated product.
3. Average defense as a per cent of gross simulated product.
4. Average exports plus imports as a per cent of gross simulated product.
5. Average per cent per period change in consumption-product ratio.
6. Average per cent per period change in investment-product ratio.
7. Average per cent per period change in defense-product ratio.
8. Average per cent per period change in trade-product ratio.

Systems 7 through 12 also used unbiased export pricing, but the null information processing rule, Rule 4, was substituted. Systems 13 through 18 were generated with the pragmatic information processing rule, but the non-economic factors of alliance preference and economic strength were introduced into the pricing of exports. Systems 19 through 24 also utilized biased export pricing, but the null information rule was used. These settings give us a two by two factorial design with six systems in each of the four cells.

Tables 26 through 33 present the results of two-way analysis of variance (fixed effects model) for each of the eight variables. The results of these analyses may be summarized in the following way. The use of Information Processing Rule 0, the pragmatic rule, produces the following effects, listed in order of decreasing magnitude.

1) The rate of increase in defense spending is substantially raised. The mean rate of increase for those systems operating under the pragmatic rule is 22.53 per cent per period, as opposed to 12.40 per cent per period for those which are not.

2) The rate of decrease in investment spending is significantly greater. For pragmatic rule systems the mean rate of decrease is 8.20 per cent per period as opposed to 3.46 per cent for the null rule systems.

TABLE 26

ANALYSIS OF VARIANCE FOR LEVEL OF CONSUMPTION

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	100.0	1	100.0	7.35	.025
Trade Parameters	0.1	1	0.1	0.01	
Interaction	0.5	1	0.5	0.04	
Error	272.2	20	13.6		
Total	372.8	23			

TABLE 27

ANALYSIS OF VARIANCE FOR LEVEL OF INVESTMENT

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	1.40	1	1.40	3.18	.10
Trade Parameters	0.02	1	0.02	0.05	
Interaction	0.02	1	0.02	0.05	
Error	8.82	20	0.44		
Total	10.26	23			

TABLE 28

ANALYSIS OF VARIANCE FOR LEVEL OF DEFENSE

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	127.0	1	127.0	7.25	.025
Trade Parameters	0.5	1	0.5	0.03	
Interaction	0.3	1	0.3	0.02	
Error	350.9	20	17.5		
Total	478.7	23			

TABLE 29

ANALYSIS OF VARIANCE FOR LEVEL OF TRADE

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	1.0	1	1.0	1.83	
Trade Parameters	301.0	1	301.0	552.40	.001
Interaction	1.5	1	1.5	2.84	
Error	10.9	20	0.5		
Total	314.4	23			

TABLE 30

ANALYSIS OF VARIANCE FOR CHANGE IN CONSUMPTION

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	12.76	1	12.76	9.18	.01
Trade Parameters	0.02	1	0.02	0.01	
Interaction	0.01	1	0.01	0.01	
Error	27.77	20	1.39		
Total	40.56	23			

TABLE 31

ANALYSIS OF VARIANCE FOR CHANGE IN INVESTMENT

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	134.9	1	134.9	11.94	.005
Trade Parameters	7.8	1	7.8	0.69	
Interaction	6.5	1	6.5	0.58	
Error	225.6	20	11.3		
Total	373.8	23			

TABLE 32

ANALYSIS OF VARIANCE FOR CHANGE IN DEFENSE

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	617.1	1	617.1	21.90	.001
Trade Parameters	0.1	1	0.1	0.00	
Interaction	2.0	1	2.0	0.08	
Error	563.3	20	28.2		
Total	1182.5	23			

TABLE 33

ANALYSIS OF VARIANCE FOR CHANGE IN TRADE

Source of Variation	Sum of Squares	Degrees of Freedom	Estimate of Variance	F	Significance
Information Rules	45.7	1	45.7	1.10	
Trade Parameters	130.2	1	130.2	3.10	.10
Interaction	38.2	1	38.2	0.92	
Error	833.3	20	41.7		
Total	1047.4	23			

3) The rate of decrease in consumption spending for pragmatic rule systems is 2.45 per cent per period, significantly different from the decrease of 0.99 per cent per period for the null rule systems.

4) The average level of consumption spending for pragmatic rule systems, 82.5 per cent, is significantly lower than that registered by null rule systems, 86.6 per cent.

5) The average level of defense spending, 13.24 per cent of the gross simulated product, is significantly greater in the pragmatic rule systems than the 8.64 per cent observed in the null rule systems.

6) Pragmatic rule systems allocate somewhat less to investment, 4.46 per cent, as opposed to 4.94 per cent for the null rule systems.

The introduction of non-economic factors in the determination of export prices has the following effects.

7) The level of trade is significantly lower in biased pricing systems. The mean trade ratio is 3.60 per cent for biased price systems as opposed to 10.68 per cent for unbiased price systems.

8) There is some evidence to suggest that the 3.23 per cent per period expansion of trade in the biased pricing systems is significantly different from the 1.43 per cent per period contraction of trade observed in the unbiased pricing systems.

No significant interaction effects were found between the two factors for any of the eight variables. In Chapter III we indicated that the international risk pricing factor (IRPF) and economic hostility buffer (EBUFF) parameters were set equal to zero to prevent a feedback loop from developing between cooperation and conflict in these runs, and the lack of significant interaction suggests that none developed. It remains for us to complete the loop in future runs and determine the effects.

We find, generally, that those systems whose nations operate under the pragmatic information processing rule are significantly more militarized than those which use the null rule. The pragmatic rule entails the use of one of the four information rules, depending upon which one seems most applicable. Unfortunately we have no record of the information rules used in this series of runs, but we can be sure that Rule 4, the null rule, was not frequently used when the pragmatic option was specified. It would appear that estimates of future behavior based on past behavior, with regard to matters of national defense, lead to significantly faster arms races. In future work we will assess the influence of each of the five rules separately.

Introducing non-economic factors into export prices significantly lowers the level of trade in the system, presumably due to the loss of profitable trades. It should be noted that if all nations traded up to the limit allowed by the international trade autarky factor (ITAF) for this

set of runs the average trade ratio would be approximately 20 per cent. In the unbiased price systems the average trade ratio is 11 per cent, indicating that approximately one-half of the permitted trade is not exchanged due to lack of opportunity. As the number of nations in the system is increased, trade opportunities should increase also, and the trade ratio is expected to rise.

We have indicated previously that trade is generally too low in the simulated systems, as compared to the referent world. We are confident that the number of nations and the autarky factor parameters will produce an increase in trade if they are increased, while the trade price parameters produce a reduction in trade if they are increased. It remains a matter for future study what blend of these parameters is optimal for the simulation of a particular referent system.

Let us turn briefly to the consideration of the effects which different initial variable settings have upon the model. In Chapter III we indicated the beginning values for consumption, investment, and defense for each of the six systems. Since the initial trade level was zero for all systems we will not be concerned with it here.

Each system's level and rate of change in consumption, investment and defense was correlated with its initial consumption, investment, and defense levels. We find that the initial consumption level correlates quite highly, .70, with the mean level of consumption and somewhat less so,

.55, with the rate of change in consumption. Both of these coefficients are significant at the .01 level. The initial setting of the consumption variable accounts for approximately one-half of the variation in the levels of consumption and somewhat less than one-third of the variation in the rates of change in consumption acrossed the twenty-four systems.

The initial investment variable settings account for a little less than one-half of the variation in subsequent system investment levels, with an r of .68, but the initial setting accounts for virtually none of the variance in rates of change in investment (r=.03).

The variation in the initial settings of the defense variable explains 36 per cent of the variation in systems defense levels (r=.60), but very little of the variation, 10 per cent, in defense rates of change (r=.31).

Since much of the behavior generated by the computer model is based on past behavior, we are not surprised to find that the subsequent values of consumption, investment and defense are significantly related to their initial values. This only tends to underscore the need to carefully select these initial values in future computer runs. It is interesting to note, however, that the initial values account for very little of the differences in the dynamic nature of the systems. These differences appear to be due to parameter variation as indicated above.

Diagnostically speaking, we see three areas for future development.

1) Investigate the specific effects of each of the five information-processing rules.
2) Examine more extensively the effects of the trade parameters.
3) Initialize systems variables with information drawn from referent materials.

6. Conclusion

What have we learned about the simulation model as a result of this analysis? Certainly one of the most important discoveries to emerge was that the model, in its present formulation, is best suited for generating long spans of time rather than short periods. The dynamic nature of the model suggests that if we wished to simulate a decade of referent time some significant revision of the model would be necessary.

On the other hand, we recognize that in some respects the parameters of the model are too rigid to allow us to replicate accurately real world behavior over a long period of time. The generation rates, for example, are constant throughout the life of the system, while it seems more reasonable to conclude that in the real world they may change over the course of one hundred years. If we elect to revise the model in order to replicate long periods of time we shall have to reexamine the constancy of some parameters.

Moreover, this objective requires the addition of certain sub-models so that we may generate certain kinds of behavior which are important when a long-range perspective is assumed. For example, over a period of 100 years the gradual or sudden movement from a bipolar to a multipolar world may have great significance for the future evolution of the system. Consequently, it will be advantageous for us to seek formulations for military conflict and alliance changes for future inclusion in the model.

In the future we should also endeavor to initiate computer runs with variable settings that correspond, as closely as possible, with known systems at some point in time. With the knowledge that we have gained here, this should be a manageable task.

On the basis of these runs, we would conclude that the model produces behavior that might be considered conservative. That is, political stability and national security seem to be the objectives that are pursued with the most vigor. The more adventurous objective of economic growth is not sought, apparently, with the same intensity. Moreover, nations in the simulated international systems appear to be rather loosely coupled economically. Many of these factors have been alluded to in the previous chapter, and it remains to be seen whether the suggested revisions will improve the model.

CHAPTER VI

CONCLUSION

We feel that we have subjected the simulation model offered here to some rather exacting tests, given the preliminary nature of the research, and we think that some discussion of the model's strengths is warranted before we consider at some length its major weaknesses. In a research project of this complexity, the failures are often more apparent than the successes, and, perhaps on this point alone, we are justified in underscoring the latter at this time.

1. The SIPER Model in Perspective

An important part of the success we feel we can claim has hitherto gone unstated; that is, the model is a viable system. By this we mean that the model did not produce national or international systems that exploded or collapsed. In the case of an iterative model, this is no mean achievement, for complex, dynamic models have demonstrated again and again their capacity to devine paths to extinction that were completely unanticipated by their designers.

Beyond this we think some credit is due the model for being able to accept a variety of input configurations without being overly sensitive to them. There is an implicit

trade-off between parameter-variable sensitivity and the viability of the model. The more sensitive a model is to parameter and variable settings, the greater the likelihood that the model will lack stability and tend to move toward extinction of one form or another. On the other hand, we must guard against the development of ultra-stable models, for their insensitivity to input variation renders them poor vehicles for experimentation and elaboration. We think that we have successfully avoided both of these pitfalls.

Our work should be viewed in relation to other international relations simulations if our accomplishment is to be appreciated. Neither Benson's "Simple Diplomatic Game" nor Reinken's computer simulation of the balance of power system are as complex as the SIPER model, and neither has been subjected to empirical evaluation. While it was not our intention to construct a model which would rival TEMPER in complexity, we do feel that our model has been subjected to more careful scrutiny than the TEMPER model, and our work must be judged accordingly. The Inter-Nation Simulation model is the only other simulation model of international phenomena that has been compared to referent data in any systematic way, and our findings here suggest that SIPER is superior to INS.

We found in Chapter IV that in about two-thirds of the relationships examined the SIPER model produced substantially the same relationship between national attributes

and national behavior as was observed in the referent system. The results of Chapter V are not so easily summarized, but it appears that the SIPER-generated systems bear substantial resemblance to the nineteenth century European state system in both their static and their dynamic properties. Both of these factors suggest that we have met with some success in modelling referent world processes.

We are pleased with the performance of the model in one final respect. The serious errors that we have uncovered appear to be rectifiable by means considerably less drastic than substantially rebuilding the model itself. These major errors seem traceable to a select set of factors rather than to the wider framework of the model. We think the model is sound enough to proceed with the incremental strategy of development that was discussed in Chapter I. This perhaps is the greatest contribution of this work. In keeping with this, let us proceed to a discussion of these major errors.

In our analysis of both national and international simulated systems we observed a recurring set of phenomena which would suggest that the model is deficient in several respects. We are referring to the high level of international economic autonomy, the low level of economic growth, and the pronounced tendency for military escalation to occur. We will discuss each one of these in turn, beginning with what we consider the least serious of the three problems.

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[illegible]

[illegible]

[illegible]

2. International Autarky

We observed in both Chapter IV and Chapter V that simulated nations trade infrequently and in small amounts. We have already discussed the factors that account for this deficiency, but they bear repeating here.

We have noted that one of the main parametric constraints on trade, the international trade autarky factor (ITAF) was given, by contemporary standards, too low a value. However, we must bear in mind that the value for ITAF, 0.10, would permit a trade-product ratio of approximately 0.20, if all nations were to trade up to their import limits. In the systems with unbiased export pricing, i.e., the high trade systems, the trade product-ratio is about one-half of what we would find if all permitted imports were made.

Deutsch and Singer have noted that as N, the number of nations in an international system, grows, the number of interaction opportunities grows by $(N^2-N)/2$. They indicate that "every nation's needs and supplies differ, and the more nations there are, the greater will be the diversity of trade-offs available to the system."[1] One of the major reasons for the relatively low level of trade in all the systems is the lack of interaction opportunities. Increasing

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[1]Karl W. Deutsch and J. David Singer, "Multipolar Power Systems and International Stability," World Politics, XVI, No. 3 (April, 1964), p. 395.

the number of nations from five to ten will raise the interaction opportunities from ten to forty-five. We think this revision can be counted upon to increase the amount of trade, but we do not know by how much.

We know as a result of our studies in Chpater V, that non-economic factors, when they are allowed to influence trade prices, can have a tremendous depressive effect on international trade. We have yet to explore in a systematic way the effects of the trade-price-bias parameters on the direction and level of trade. There are, however, encouraging developments in the field of international economics which indicate that the field is becoming increasingly aware of the interaction between international economic and political phenomena.[2] We foresee that we will have the benefit of this work in the future.

One more point deserves further elaboration. The model as it stands is non-spatial. There is no geographic reality, and as we proceed to adapt the model for simulating particular systems or subsystems, the need to introduce the factors of national proximity and continuity becomes more pressing. Spatial proximity and continuity are important factors in both international cooperation and international conflict,[3] and we shall have to think seriously about adding

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[2]A very recent example is Charles P. Kindleberger, Power and Money (New York: Basic Books, 1970).

[3]See, for example, James P. Wesley, "Frequency of Wars and Geographical Opportunity," Journal of Conflict Resolution, VI, No. 4 (December, 1962), pp. 387-389.

a spatial dimension to the simulated international systems.

Ragnar Nurske has pointed out that international trade has served as "the engine for growth" in the international system.[4] It has encouraged national specialization and disseminated technology throughout the system. The low level of international exchange we observed in the simulated international systems explains in part the next general problem we will discuss, i.e., economic stagnation.

3. Economic Stagnation

Our observation concerning the dynamic nature of the model and the systems it produces indicates that the model's performance with respect to economic growth is less than satisfactory. Part of this can be explained by the low levels of investment which we found characteristic of the simulated nations. However, the rate of economic growth, given a certain level of investment, is also dependent upon the depreciation rate of national productive resources.

Currently, the depreciation rate is either 2, 5, or 10 per cent, depending upon a stochastic determination where each value has an equal probability of being selected. This procedure seems questionable from several points of view. It seems likely that depreciation rates, rather than being random, are systematically related to the level

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[4] Ragnar Nurske, "Patterns of Trade and Development," Economics of Trade and Development, ed. James D. Theberge (New York: Wiley, 1968), pp. 85-102.

of economic development. We suspect that the more developed a country is, the higher the depreciation rate. If this suspicion is borne out in future empirical work, we anticipate reformulating the depreciation process so that depreciation rates are related to generation rates.

The generation rates themselves, however, pose serious questions. They have been held constant throughout these runs, and the model contains no process by which they can be changed. Here we face fundamental conceptual difficulties.

There are certain conceptual ambiguities in the economic system which have serious long term consequences. In the present formulation gross simulated product is equal to the total consumption, investment, and defense goods produced by a national system.

$$GSP = CS + BC + FC$$
$$= a_1 * CSGR * TBC + a_2 * BCGR * TBC + a_3 * FCGR * TBC$$

There are only two ways in which national product can expand in this formulation if we hold the generation rates constant. The set of a_k values may be altered so that TBC is transferred from sectors with lower generation rates to sectors with higher generation rates. In the referent world this kind of process is encouraged by the forces of comparative advantage, and growth by specialization is common. However, there are limits to how much growth may be generated in this way, and when trading activity is low,

as it is in the simulated systems, the amount of growth that can be generated in this way is quite small.

The other possible way to expand national product is to increase the national resource capability (TBC). In the present formulation, the production of BC value increases the national resource capability.

$$TBC(I,T) = TBC(I,T-1) + a_2*BCGR*TBC(I,T-1) - DPTBC*TBC(I,T-1)$$

Total basic capability is the total of human and non-human productive resources available to a nation. While we can readily see how investment through the production of BC value, can increase the non-human productive factors, the conceptualization falters when we examine the connection between investment and the expansion of human resources. In other words, investment contributes directly to the quantitative and qualitative expansion of technology, but its relationship to population growth seems, at best, an indirect one.

Moreover, if we were to assume that TBC represents only non-human production factors, we would be forced to argue that the generation rates, which are constant, represent the quantity and quality of human resources. This would clearly be an argument that we are not prepared to make.

If we reverse the conceptualization and suggest that TBC represents human resources and the generation rates represent the quantitative and qualitative aspects of non-

human resources, we have a formulation that is more satisfying for a variety of reasons. A very large proportion of short term economic growth is due to population growth, and, consequently, if we are to hold anything constant it seems more reasonable to freeze the level of technology, as embodied in the generation rates, rather than the size of the population. Furthermore, the assumption that TBC represents population and the generation rates represent the level of development allows us to take advantage of much work that has been done by economists and estimate values for these variants from real world data.

We still have the original problem of how investment causes population growth; that is, how BC production increases TBC. We propose to reformulate this relationship so that BC production contributes to the growth of generation rates, and CS production contributes to the growth of TBC, or population.

While this reformulation is still in an early stage of development, we believe that it will enable us to introduce some interesting dynamic aspects. For example, we will be able to simulate nations with high population growth rates and low developmental growth rates, like contemporary India, or low population growth rates and high developmental growth rates, like late-nineteenth century France. The separation of human from non-human productive resources will enable us to introduce diffusion of technology and population migration dynamics as well. We foresee, ultimately,

that we will be able to generate a greater variety of economic growth patterns.

However, it is likely that this reformulation, given the same level of investment that we observed in these systems, would not produce the kind of growth dynamics desired. This, for the most part, is due to the tendency for simulated nations to devote larger and larger proportions of their national resources to defense.

4. Military Escalation

An arms race has been defined as the situation where "rival states stimulate one another to divert increasing proportions of their national income to military preparations."[5] A review of Table 25 in Chpater V indicates that all of the simulated systems are characterized by arms races. The slowest of these races is found in system 21 where the average proportion of national income devoted to defense grew by 7.1 per cent per period. The fastest race, 31.4 per cent per period, is found in system 5.

We found in Chapter V that much of the variance in the speed of arms races could be explained by the information processing rule used, as we noted the need to study systematically the effects of these rules. Beyond this, however, we must recognize the fundamental tendency for the model to generate arms races. We suspect that these rules

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[5]Deutsch and Singer, *op. cit.*, p. 391.

may increase or decrease the speed of arms races, but they will not effect the occurrence of arms races. To find the causal agent responsible for the arms races we must look elsewhere.

The first factor we must consider is the rather obvious one that little provision has been made in the present model for major powers to lower defense expenditures. The major policy alternative that is evaluated is whether to keep defense spending where it is or to increase it, not to decrease it. This leaves us with only equilibrium or escalation as possible outcomes. Why don't we find equilibrium in any of the systems?

The argument for the emergence of equilibrium seems particularly sound when we recall that the major powers are motivated by what may be called "parity deterrence." That is, the power that is behind in the arms race does not seek superiority over the leader, but rather, it desires only to match the leader's power.

When equality between the two powers is attained, they are both satisfied and feel no impetus to increase the proportion of resources devoted to defense. Once the parity point is reached the two powers will be in a stable equilibrium.

We do not observe such equilibria principally because of the depreciation of total force capability (TFC). The stochastic choice of depreciation rates introduces shocks into the interaction system of the two competing powers.

may increase

[illegible]

[illegible]

These distrubances push the system off its equilibrium point in an escalating direction in the following way.

Suppose powers A and B are in an equilibrium position; that is, both have the same level of total force capability, and neither wishes to increase the proportion of resources allocated to defense. TFC depreciates each period, and the depreciation rates are quite high. The rates 0.2, 0.3, and 0.4 have an equal probability of being selected. There is a one-third probability that, in a given period, powers A and B will suffer the same rate of depreciation. If this happens, the equilibrium will not be disturbed since a gap between the powers will not appear. If, on the other hand, they experience different depreciation rates, which may be expected to happen in two out of every three periods of time, a gap may develop between the powers such that one of them is encouraged to increase the proportion of resources devoted to defense. Since this proportion will not drop, it seems highly unlikely that the powers could avoid military escalation for any length of time.

It does not seem reasonable to maintain the depreciation mechanism in its present form. Referent decision-makers have sufficient information about the peace-time depreciation of their force capability, and they can adjust their defense allocation accordingly. Some unpredictable depreciation remains, but the stochastic variability of depreciation rates should be reduced and, perhaps,

normally distributed. It is clear that we shall have to reformulate the depreciation processes throughout the model.

The ability to anticipate and compensate for force depreciation will permit the attainment of equilibrium, but it will not make possible military deescalation. To do this we shall need to reformulate the aspiration-level-for-national-security mechanism such that provision is made for the lowering of defense expenditures.

At this point we can only suggest some factors that we wish to include in the reformulation. The present simulated nations react only to the existence of a gap. Modifications should be made such that rates of gap closure are monitored also. Thresholds should be introduced where actions that increase, decrease, or maintain arms are activated. Furthermore, nations must be aware of approaching their maximum feasible allocation of resources to defense. All of these factors require some substantial theoretical and empirical work before they can be incorporated into the model. We believe, however, that the reformulation will improve the military dynamics of the model.

Often, in the past, nations have reacted to a military challenge by doing more than increasing arms. One frequent response has been to seek and secure allies. This strategy is not available to the simulated nations, and its absence points up an important deficiency in the model. Alliance

structures are not changed internally, but must be introduced as input. If the model is to have any long range predictive power, we must be prepared to produce these changes internally. Therefore, we resolve to add the necessary processes to produce dynamic alliance structures in the near future.

However, we must bear in mind that approximately one-half of recent arms races have ended in war.[6] The model includes no procedures by which the simulated nations can bring their arms races to an end in this manner. Consequently, until the addition of military conflict to the model, we are likely to observe in some cases the generation of arms races which do not end short of the collapse of the system.

Finally, it is clear to us that, for reasons of assessing validity, we must set up simulated worlds as much like a particular referent time and place as we can. This approach will demand an extensive data base, and the compilation of such a data base is as important as reformulating the model.

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[6]Samuel P. Huntington, "Arms Races: Prerequisites and Results," Approaches to Measurement in International Relations, ed. John E. Mueller (New York, Appleton-Century-Crofts, 1969), pp. 15-33.

APPENDIX

THE COMPUTER PROGRAM

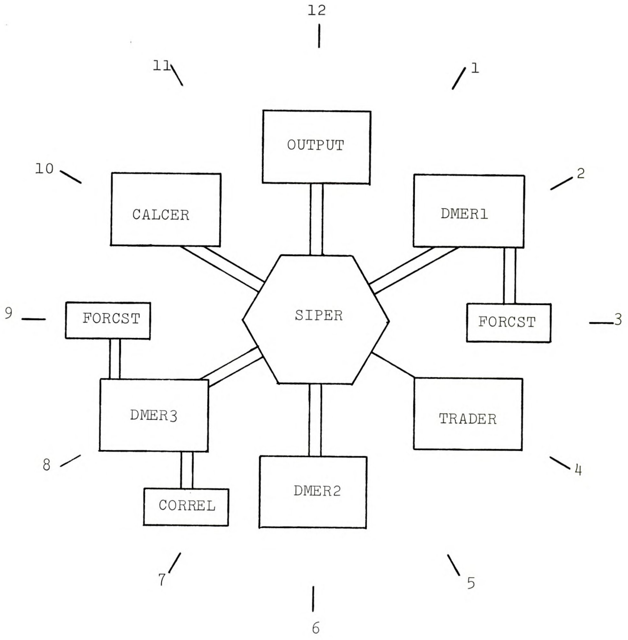
The computer program that follows is written in FORTRAN IV, and is designed to operate on the Control Data Corporation 6400-6500-6600 computing systems. The use of other computing systems might require slight alterations.

The program is composed of eight subroutines and a main executive routine. Figure 19 indicates the sequence in which the subroutines are executed in one period of simulated time. Two solid lines represent iterative passage of control from one routine to another while a single solid line indicates that a routine is called only once in each cycle.

A period of simulated time begins at about one o'clock on the execution clock in Figure 19. The first routine called, DMER1, is concerned with revising aspiration levels and setting export prices. TRADER, the next routine called by the executive routine, negotiates and concludes trades between the simulated nations. DMER2 revises the national product decisions in accordance with trade commitments, resolves budget crises should they arise, and assesses the need for foreign aid. The granting of aid and the expression of hostility is handled by DMER3. CALCER calculates the consequences of decisions made and prepares the system for

FIGURE 19

PROGRAM EXECUTION SEQUENCE



the next period. OUTPUT, as the name implies, transfers summary information about the period to the appropriate output device.

The program has several input/output options. The user may specify at what intervals data is to be read in and the model set back on some prescribed track. For example, it is possible to specify that after each period of decision-making, data is read from the referent input tape, and this information is substituted for the model-generated data before the next period begins. In this way single-period differences between referent and simulated behavior may be studied.

On the output side, there is provision for specifying detailed print-out of all decision-making or specific portions of the decision-making cycle. In addition, summary information may be printed and/or written on tape at the end of each period.

Our estimates of space, time and cost are as follows. The program requires approximately 50,000 octal memory locations, and one period of decision-making for a five-nation world requires approximately one-half of a second of central processer time. Our cost estimate for a Control Data Corporation 6500 computing system is less than one cent per nation per period. This estimate does not include compilation costs or peripheral processing costs, which may vary. We would estimate the basic cost of generating the twenty-four systems we have analyzed to be under twenty dollars.

```
PROGRAM SIPER (INPUT, OUTPUT, TAPE 1, TAPE 2)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
1T(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), GSPO(5), BCPO(5), FCPO(5), BCCS(5), BCBC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), CSMIN(5), VSCSCA(5,12), ALREAD(12
$)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,RDPAY,GSP,CSMIN,VSCSCA
REAL IMPORT,IMLIM,IMBC,IMGSP
INTEGER T
REWIND 2
PRINT 21
READ 24, NPERDS,INSWIN,IPRIN1,IPRIN2,IPRIN3,IPRIN4,NRUN,IRTAPE,INT
1DAT,N,NC,ISTEP,IPRIN5
PRINT 22, ISTEP,N,NC,NRUN,NPERDS
NT=NPERDS+1
READ 27, (PAR(J),J=1,12),(W(J),J=1,3),(IRSSUP(J),J=1,5),(PAR(J),J=
113,18)
PRINT 25, (PAR(J),J=1,12)
PRINT 26, (W(J),J=1,3),(IRSSUP(J),J=1,5),(PAR(J),J=13,16)
READ 28, (LEAD(J),J=1,5),(ALPOH(J,1),J=1,5),(ALGRO(J,1),J=1,5),(AL
1SEC(J,1),J=1,5)
DO 1 I=1,N
WAR(I)=0
READ 29, (GR(I,J),J=1,NC),(ALLY(I,J),J=1,N)
```

```
READ 36, (VSCSCA(I,J),J=1,12)
DO 1 J=1,N
ITRANS(I,J)=5*(I-1)+J
1 CONTINUE
DO 16 IZZ=1,NRUN
DO 2 I=1,N
DO 2 J=1,N
DO 2 K=1,12
HOST(I,J,K)=0
HOST(I+1,J+1,K)=0
AID(I,J,K)=0
TRADE(I,J,K)=0
2 CONTINUE
READ 23, (ALREAD(J),J=1,12)
IRUN=IZZ+9
DO 3 T=1,2
DO 3 I=1,N
READ (2,32) TBC(I,T),TFC(I,T),PDTBC(I,T),PDTFC(I,T),CSMIN(I),RDPAY
1(I),DDLV(I),VSCS(I),VSNS(I),VSM(I,T),POH(I,T),DL(I,T),PR(I,T), REV(
2I,T),(HOST(I,J,T),J=1,6),CSPO(I),BCPO(I),FCPO(I),CSP(I,1),BCP(I,1)
3,FCP(I,1),FICP(I,1),BCCS(I),BCBC(I),BCFC(I),CS(I),BC(I),FC(I),DDLC
4(I),(TXPORT(I,J),J=1,3),(TMPORT(I,J),J=1,3),GSP(I),(EXBC(I,J),J=1,
56),(IMBC(I,J),J=1,6),(EXGSP(I,J),J=1,6),(IMGSP(I,J),J=1,6)
DO 3 J=1,N
TRADE(J,I,1)=IMBC(I,J)
3 CONTINUE
DO 15 T=2,NT
IF (IPRIN4.EQ.1) PRINT 33, T
IF (ALREAD(T).NE.1.) GO TO 4
READ 23, ((ALLY(I,J),J=1,N),I=1,N)
4 CONTINUE
DO 5 I=1,N
CSMF(I)=CSMIN(I)/(TBC(I,T)*GR(I,1))
ABC(I)=(1.-CSMF(I))*TBC(I,T)
IF (LEAD(I).NE.1) GO TO 5
```

```
GO TO 12
10 DO 11 JK=1,12
READ (2,35) (CARD(L),L=1,8)
IF (IRTAPE.NE.1) GO TO 11
IF (INTDAT.EQ.1) WRITE (1,35) (CARD(L),L=1,8)
11 CONTINUE
12 DO 13 J=1,N
TRADE(J,I,T)=IMBC(I,J)
13 CONTINUE
14 CONTINUE
15 CONTINUE
16 CONTINUE
IF (IRTAPE.EQ.0) GO TO 20
IF (INTDAT.EQ.1) GO TO 20
REWIND 2
DO 19 I=1,NRUN
DO 17 J=1,120
READ (2,34) IDUMMY
17 CONTINUE
DO 18 J=1,600
READ (2,35) (CARD(K),K=1,8)
WRITE (1,35) (CARD(K),K=1,8)
18 CONTINUE
19 CONTINUE
20 CONTINUE
C
C
21 FORMAT (1H1,*SIPER, VERSION II*)
22 FORMAT (1H0,61X,*THIS RUN WILL READ IN DATA AFTER *,I3,/61X,* PERIO
1D(S). IT INCLUDES *,I1,* NATIONS WITH *,I1,/61X,* ECONOMIC SECTOR
2S. IT WILL DO *,I2,* SYSTEM(S) OF *,/61X,12,* TIME PERIODS EACH.*)
23 FORMAT (5X,25F1.0)
24 FORMAT (I2,5I,I2,I1,I1,3I2,I1)
25 FORMAT (1H0,20X,*DECISION PARAMETERS*/1X,6F10.4/1H0,20X,*THREAT*/2
11X,F10.4//21X,*ASPIRATION FEEDBACKS*/21X,3F10.4//21X,*TRADE PRICE
2BIAS*/21X,2F10.4)
```

```
26 FORMAT (1HO,*WAYS FOR NORMALIZING *,10X,*INFORMATION OPTIONS SE
1LECTED*/1X,3F7.2,10X,516/1HO,*EXPECTED HOSTILITY*,10X,*ARMS/HOSTIL
2ITY*,10X,*ALLY TOLERANCE*/5X,*COEFFICIENT*,15X,* COEFFICIENT*,13X,
3*COEFFICIENT*//5X,F10.4,16X,F10.4,14X,F10.4///1X,*TRADE VOLUME PAR
4AMFTER*/7X,F10.4)
27 FORMAT (10F8.0,/5F8.0,5I8/10F8.0)
28 FORMAT (5I5/5F7.0/5F7.0/5F7.0)
29 FORMAT (3F7.0/10F7.0)
30 FORMAT (1H1,///10X,*SIMULATE RESULTS FOR NATION*,I2)
31 FORMAT (1HO,///10X,*WINSAFE RESULTS FOR NATION*,I2)
32 FORMAT (2(5X,7F10.0/),5X,6F10.0//3(5X,7F10.0/),4(5X,6F10.0/))
33 FORMAT (1H1//30X,30H******************************/30X,2H**,26X,2H
1**/30X,2H**,8X,*PERIOD *,I3,8X,2H**/30X,2H**,26X,2H**/30X,30H*****
2*************************)
34 FORMAT (I5)
35 FORMAT (8A10)
36 FORMAT (F10.0,11F6.0)
END
SUBROUTINE FORCST (N,EST,IRSSUP)
DIMENSION ESTI(3), W(3)
COMMON DATUM(20)
REAL N1
IF (N.EQ.2) GO TO 13
IF (IRSSUP.EQ.4) GO TO 13
IF (IRSSUP.NE.0) INFRUL=IRSSUP
IF (IRSSUP.NE.0) GO TO 8
IND=0
NA=N-11
IF (NA) 2,1,1
1 L=N-10
GO TO 3
2 L=1
3 NP=N-L
N=N-1
4 S1=0
```

```
CALL DMER1 (I,N,T,NC,IPRIN2,INSWIN)
5 CONTINUE
DO 6 I=1,N
IF (LEAD(I).EQ.1) GO TO 6
CALL DMER1 (I,N,T,NC,IPRIN2,INSWIN)
6 CONTINUE
CALL TRADER (N,NC,IPRIN1)
DO 7 I=1,N
CALL DMER2 (I,N,T,IPRIN3,NC)
7 CONTINUE
DO 8 I=1,N
IF (LEAD(I).EQ.0) GO TO 8
CALL DMER3 (I,T,N,NC,IPRIN5)
8 CONTINUE
DO 9 I=1,N
IF (LEAD(I).EQ.1) GO TO 9
CALL DMER3 (I,T,N,NC,IPRIN5)
9 CONTINUE
CALL CALCER (N,T,INSWIN)
DO 14 I=1,N
IF (IPRIN4.EQ.1) PRINT 30, I
CALL OUTPUT (I,T,IRUN,1,IPRIN4,IRTAPE)
IF (ISTEP.EQ.0) GO TO 10
ABC=FLOAT(T)/FLOAT(ISTEP)
CDF=INT(ABC)
IF (ABC.NE.CDF.) GO TO 10
READ (2,32) TRC(I,T+1),TFC(I,T+1),PDTBC(I,T+1),PDTFC(I,T+1),CSMIN(
1I),RDPAY(I),DDLV(I),VSCS(I),VSNS(I),VSM(I,T+1),POH(I,T+1),DL(I,T+1
2),PR(I,T+1),REV(I,T+1),(HOST(I,J,T+1),J=1,6),CSPO(I),BCPO(I),FCPO(
3I),CSP(I,T),BCP(I,T),FCP(I,T),FICP(I,T),BCCS(I),BCBC(I),BCFC(I),CS
4(I),BC(I),FC(I),DDLC(I),(TXPORT(I,J),J=1,3),(TMPORT(I,J),J=1,3),GS
5P(I),(EXBC(I,J),J=1,6),(IMBC(I,J),J=1,6),(EXGSP(I,J),J=1,6),(IMGSP
6(I,J),J=1,6)
IF (IPRIN4.EQ.1) PRINT 31, I
CALL OUTPUT (I,T,IRUN,INTDAT,IPRIN4,IRTAPE)
```

```
S2=0
S3=0
S4=0
DO 5 I=L,N
B=I
S1=B*DATUM(I)+S1
S2=B+S2
S3=DATUM(I)+S3
S4=B**2+S4
5 CONTINUE
N1=NP
SLOPE=(N1*S1-S2*S3)/(N1*S4-S2**2)
CONST+(S3-SLOPE*S2)/N1
ESTI(1)=CONST+SLOPE*(N1+1.)
ESTI(2)=S3/N1
ESTI(3)=DATUM(N)*2./DATUM(N-1)
IF (IND.EQ.1) GO TO 12
DO 6 J=1,3
W(J)=ABS(DATUM(N+1)-ESTI(J))
6 CONTINUE
WLOW=1000000.
DO 7 J=1,3
IF (W(J).GT.WLOW) GO TO 7
INFRUL=J
WLOW=W(J)
7 CONTINUE
N=N+1
8 NA=N-10
IF (NA) 10,9,9
9 L=N-9
GO TO 11
10 L=1
11 NP=N-1+1
IND=1
GO TO 4
```

```
12 EST=ESTI(INFRUL)
IRS=INFRUL
RETURN
13 EST=DATUM(N)
IRS=4
RETURN
C
END
SUBROUTINE DMER1 (I,N,T,NC,IPRINT,INSWIN)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3),IMPOR
1T(10,10,3),IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10)  WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), CSPO(5), BCPO(5), FCPO(5), BCCS(5), BCBC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), CSMIN(5), VSCSCA(5,12)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,RDPAY,GSP,CSMIN,VSCSCA
REAL IMPORT,IMLIM,IMBC,IMGSP,IPOW
INTEGER T
ALOW=100000.
DO 1 J=1,N
IF (I.EQ.J) GO TO 1
IF (ABS(TBC(I,T)-TBC(J,T)).GT.ALOW) GO TO 1
M=J
ALOW=TBC(J,T)
1 CONTINUE
AM2=PAR(2)
```

```
IF (ALPOH(I,T-1).GT.POH(I,T)) AM2=AM2/2.
ALPOH(I,T)=PAR(1)*APOH(I,T-1)+AM2*(POH(I,T)-ALPOH(I,T-1))+PAR(3)*
1(POH(M,T)-POH(I,T))
AM5=PAR(5)
IF (ALGRO(I,T-1).GT.PDTBC(I,T)) AM5=AM5/2.
ALGRO(I,T)=PAR(4)*ALGRO(I,T-1)+AM5*(PDTBC(I,T)-ALGRO(I,T-1))+PAR(6
1)*(PDTBC(M,T)-PDTBC(I,T))
IF (LEAD(I).NE.1) GO TO 9
APOW=0
OPOW=0
ALWEL=0
DO 3 J=1,N
ALWEL=ALWEL+ABC(J)*GR(J,3)*ALLY(I,J)
DO 2 K=1,T
DATUM(K)=TFC(J,K)
2 CONTINUE
IRS=IRSSUP(I)
CALL FORCST (T,EST,IRS)
TFC(J,T+1)=EST
IF (IPRINT.EQ.1) PRINT 26, IRS,J,TFC(J,T+1)
APOW=APOW+ALLY(I,J)*TFC(J,T+1)
OPOW=OPOW+ABS(ALLY(I,J)-1.)*TFC(J,T+1)
3 CONTINUE
IF (IPRINT.EQ.1) PRINT 32, I,OPOW,APOW
IF (OPOW-APOW) 6,4,4
4 DO 5 J=1,N
AS=((ABC(J)*GR(J,3))/ALWEL)*(OPOW-APOW)*ALLY(I,J)
AT=(AS/GR(J,3))/TBC(J,T)
IF (IPRINT.EQ.1) PRINT 39, I,J,AS,AT
FCCUE(I,J)=(FCP(J,T-1)+AT)*ALLY(I,J)
5 CONTINUE
GO TO 8
6 DO 7 J=1,N
FCCUE(I,J)=FCP(J,T-1)*ALLY(I,J)
7 CONTINUE
```

```
8 CONTINUE
IF (IPRINT.EQ.1) PRINT 33, I,(FCCUE(I,J),J=1,N)
ALSEC(I,T)=FCCUE(I,I)
GO TO 20
9 AD=0
DO 11 J=1,N
IF ((ALLY(I,J)*LEAD(J)).EQ.1) IL=J
IF (ALLY(I,J).EQ.1) GO TO 11
DO 10 K=1,T
DATUM(K)=HOST(J,I,K)
10 CONTINUE
IRS=IRSSUP(I)
CALL FORCST (T,EST,IRS)
HOST(J,I,T+1)=EST
AD=AD+PAR(7)*EST*TFC(J,T+1)
11 CONTINUE
IF (IPRINT.EQ.1) PRINT 34, I,AD
IF (AD-TFC(I,T+1)) 13,12,12
12 ALSEC(I,T)=FCP(I,T-1)+(AD-TFC(I,T+1))/GR(I,3)/TBC(I,T)
IF (IPRINT.EQ.1) PRINT 35, I,ALSEC(I,T)
GO TO 14
13 ALSEC(I,T)=ALSEC(I,T-1)
14 IF (ALSEC(I,T).LT.FCCUE(IL,I)) GO TO 15
ALSEC(I,T)=FCCUE(IL,I)
GO TO 20
15 AF=0
AG=0
NIP=T-1
DO 17 K=1,NIP
DO 16 J=1,N
AF=AF+TRADE(J,I,K)+AID(J,I,K)
16 CONTINUE
AG=AG+TRADE(IL,I,K)+AID(IL,I,K)
17 CONTINUE
IF (AF.EQ.0) UPOW=0
```

```
IF (AF.EQ.0) GO TO 18
UPOW=AG/AF
18 AH=0
IF (IPRINT.EQ.1) PRINT 36, I,AG,AF,UPOW
AP=0
DO 19 J=1,N
AH=AH+DL(J,T)
AP=AP+DL(J,T)**2
19 CONTINUE
AN=FLOAT(N)
AQ=SQRT((AP-AH**2/AN)/AN)
AR=AINT((AN-1.)/2.+.5*5.4/AN+AINT(AN/2.+.5)*3.6/AN
IPOW=AQ/AR*(1.-ABS(DL(I,T)-DL(IL,T))/(DL(I,T)+DL(IL,T)))
IF (IPRINT.EQ.1) PRINT 37, I,AQ,AR,IPOW
ALSEC(I,T)=ALSEC(I,T)+(FCCUE(IL,I)-ALSEC(I,T))*((UPOW+IPOW)/2.)
IF (IPRINT.EQ.1) PRINT 38, I,ALSEC(I,T)
20 CONTINUE
CSP(I,T)=CSP(I,T-1)+PAR(8)*(ALPOH(I,T)-POH(I,T))*ABS(CSP(I,T-1))+P
1AR(10)*PR(I,T)
IF (CSP(I,T).LT.CSMF(I)) CSP(I,T)=CSMF(I)
BCP(I,T)=BCP(I,T-1)+PAR(9)*(ALGRO(I,T)-PDTBC(I,T))*ABS(BCP(I,T-1))
FCP(I,T)=ALSEC(I,T)
DM11=.3
FICP(I,T)=FICP(I,T-1)+DM11*PR(I,T)
IF (FICP(I,T).GT..3) FICP(I,T)=.3
IF (IPRINT.EQ.0) GO TO 21
PRINT 27, I,ALPOH(I,T),ALGRO(I,T),ALSEC(I,T)
PRINT 28, I
PRINT 29, CSP(I,T),BCP(I,T),FCP(I,T)
A6=CSP(I,T)*TBC(I,T)*GR(I,1)
A7=BCP(I,T)*TBC(I,T)*GR(I,2)
A8=FCP(I,T)*TBC(I,T)*GR(I,3)
PRINT 30, A6,A7,A8
PRINT 31, IMLIM(I,1),IMLIM(I,2),IMLIM(I,3)
TOTIM=PAR(16)*TBC(I,T)
```

```
      A4=CSP(I,T)-CSMF(I)
      IF (IPRINT.EQ.1) PRINT 40,  I,TOTIM,A4
      A5=A4+BCP(I,T)+FCP(I,T)
      IMLIM(I,1)=A4/A5*TOTIM
      IMLIM(I,2)=BCP(I,T)/A5*TOTIM
      IMLIM(I,3)-FCP(I,T)/A5*TOTIM
   21 DO 25 J=1,N
      IF (I.EQ.J) GO TO 25
      DO 24 K=1,NC
      DO 23 L=1,NC
      IF (K.EQ.L) GO TO 23
      MA=ITRANS(I,J)
      HTRAD=0
      IF (HOST(I,6).LE.0) GO TO 22
      HTRAD=HOST(I,J)/HOST(I,6)*ALOG10(HOST(I,6)+1.)
   22 CONTINUE
      EXPRC(MA,K,L)=(GR(J,L)*GR(I,L)*(GR(I,K)*GR(J,K)))/(GR(I,K)*GR(J,K)
     1*(GR(I,L)+GR(J,L)))
      EXPRC(MA,K,L)=EXPRC(MA,K,L)-PAR(11)*(2.*ALLY(I,J)-1.)*EXPRC(MA,K,L
     1)+PAR(12)*((TBC(J,T)/(TBC(J,T)+TBC(I,T)))-.5)*EXPRC(MA,K,L)+PAR(18
     2)*HTRAD*EXPRC(MA,K,L)
   23 CONTINUE
   24 CONTINUE
   25 CONTINUE
      DDLC(I)=0
      RETURN
C
C
   26 FORMAT (61X,*INFORMATION RULE *,I1,* WAS USED TO ESTIMATE VALUE FO
     1R *,I1,/61X,*.  THE VALUE THUS ESTIMATED WAS *,F10.1)
   27 FORMAT (1HO,20X,*ASPIRATION LEVELS FOR *,I2//1X,*ALPOH=*,F5.3,7X,*
     1 ALGRO=*,F5.3,7X,*ALSEC=*,F5.3)
   28 FORMAT (1HO,20X,*PRELIMINARY DECISIONS FOR *,I2/15X,*CS*,12X,*BC*,
     112X,*=C*)
   29 FORMAT (1X,*GOALS-TBCPC*,3(F7.3,7X))
```

```
30 FORMAT (1X,*SIM PRODUCT  *,3(F7.0,7X))
31 FORMAT (1X,*IMPORT LIMITS*,3(F7.1,7X))
32 FORMAT (1X/60X,*LEADER *,I1,*.  OPOW=*,F10.1,*.  APOW=*,F10.1)
33 FORMAT (1X/60X,*LEADER *,I1,*. CUES =*,5F6.3)
34 FORMAT (1X/60X,*NATION *,I1,*.  AD=*,F10.1,)
35 FORMAT (1X/60X,*NATION *,I1,*.  ALSEC=*,F6.3)
36 FORMAT (1X/60X,*NATION *,I1,*.  AG=*,F10.1,*  AF=*,F10.1,*  UPOW=
1*,F10.)
37 FORMAT (1X/60X,*NATION *,I1,*.  AQ=*,F10.3,*  AR=*,F10.3,*  IPOW=
1*,F10.5)
38 FORMAT (1X/60X,*NATION *,I1,*.  NEW ALSEC=*,F10.5)
39 FORMAT (1X,/60X,*LEADER *,I1,* ALLY *,I1,*      AS=*,F10.4, *AT=*
1,F10.4)
40 FORMAT (1X/60X,*NATION *,I1,*  TOTIM=*,F10.4,*  A4=*,F10.4,*   X2
1=*,F10.4)
END
SUBROUTINE TRADER (N,NC,IPRINT)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
1T(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22),FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), DOMPRC(10,3), WDEAL(25,3,3), IBID(25,3,3), IMPRC(25,3,3)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS
REAL IMPORT,IMLIM,IMBC,IMGSP,IMPRC
DO 1 I=1,N
DO 1 J=1,N
MA=ITRANS(I,J)
DO 1 K=1,NZ
EXPORT(I,J,K)=0
IMPORT(I,J,K)=0
DO 1 L=1,NC
IMPRC(MA,K,L)=0
```

```
WDEAL(MA,K,L)=0
IBID(MA,K,L)=0
1 CONTINUE
DO 2 I=1,N
DO 2 J=1,N
MA=ITRANS(I,J)
MB=ITRANS(J,I)
DO 2 K=1,NC
DOMPRC(I,K)=1.0/GR(I,K)
DO 2 L=1,NC
IF ((I.EQ.J).OR.(K.EQ.L)) GO TO 2
IMPRC(MA,K,L)=EXPRC(MB,K,L)/GR(I,L)
IF (IMPRC(MA,K,L).GE.DOMPRC(I,K)) GO TO 2
WDEAL(MA,K,L)=DOMPRC(I,K)-IMPRC(MA,K,L)
2 CONTINUE
DO 11 IA=1,12
IF (IPRINT.EQ.1) PRINT 13, IA
DO 4 I=1,N
BEST=0
DO 3 J=1,N
MA=ITRANS(I,J)
DO 3 K=1,NC
DO 3 L=1,NC
IF (WDEAL(MA,K,L).LE.BEST) GO TO 3
BEST=WDEAL(MA,K,L)
IJ=J
IK=K
IL=L
3 CONTINUE
MC=ITRANS(I,IJ)
IF (WDEAL(MC,IK,IL).LE.0) GO TO 4
IBID(MC,IL,IK)=1
WDEAL(MC,IK,IL)=(-1.)
4 CONTINUE
DO 9 I=1,N
```

```
DO 9 J=1,N
IF (I.EQ.J) GO TO 9
DO 9 K=1,NC
MA=ITRANS(I,J)
MB=ITRANS(J,I)
DO 9 L=1,NC
IF (K.EQ.L) GO TO 9
IF (IBID(MA,K,L).NE.1) GO TO 9
IF (IBID(MB,L,K).NE.1) GO TO 9
IF (IMLIM(I,L).LE.0) GO TO 9
IF (IMLIM(J,K).LE.0) GO TO 9
IF (IMLIM(I,L)-IMLIM(J,K)) 6,5,5
5 IM=J
IM1=L
IN=I
IN1=K
GO TO 7
6 IM=I
IM1=K
IN=J
IN1=L
7 CONTINUE
Y2=IMLIM(IM,IN1)/DOMPRC(IM,IN1)
IP=ITRANS(IM,IN)
Y1=Y2/EXPRC(IP,IM1,IN1)
TRDCST=2.
IF ((Y2*DOMPRC(IM,IN1)-Y1*DOMPRC(IM,IM1)).LT.TRDCST) GO TO 8
IF ((Y1*DOMPRC(IN,IM1)-Y2*DOMPRC(IN,IN1)).LT.TRDCST) GO TO 8
B1=Y1*DOMPRC(IM,IM1)
EXPORT(IM,IN,IM1)=EXPORT(IM,IN,IM1)+Y1*DOMPRC(IM,IM1)
B2=Y1*DOMPRC(IN,IM1)
IMPORT(IN,IM,IM1)=IMPORT(IN,IM,IM1)+Y1*DOMPRC(IN,IM1)
B3=Y2*DOMPRC(IN,IN1)
EXPORT(IN,IM,IN1)=EXPORT(IN,IM,INL)+Y2*DOMPRC(IN,IN1)
B4=Y2*DOMPRC(IM,IN1)
```

```
IMPORT(IM,IN,IN1)=IMPORT(IM,IN,IN1)+Y2*DOMPRC(IM,IN1)
IMLIM(IN,IM1)=IMLIM(IN,IM1)-Y1*DOMPRC(IN,IM1)
IF (IMLIM(IN,IM1).LT.1.) IMLIM(IN,IM1)=0
IMLIM(IM,IN1)=IMLIM(IM,IN1)-Y2*DOMPRC(IM,IN1)
IF (IMLIM(IM,IN1).LT.1.) IMLIM(IM,IN1)=0
IF (IPRINT.NE.1) GO TO 8
PRINT 14, I,K,J,L
PRINT 15, IM,IN,B1,IM1,B4,IM1
PRINT 15, IN,IM,B3,IN1,B2,IM1
8 CONTINUE
MA=ITRANS(I,J)
MB=ITRANS(J,I)
IBID(MA,K,L)=0
IBID(MB,L,K)=0
9 CONTINUE
NA=0
DO 10 I=1,N
DO 10 K=1,NC
IF (IMLIM(I,K).LE.0) NA=NA+1
10 CONTINUE
IF (NA.EQ.(N*NC-1)) GO TO 12
11 CONTINUE
12 CONTINUE
RETURN
C
C
13 FORMAT (1HO,20X,*TRADE ROUND *,I2)
14 FORMAT (1HO,*NATION *,I1,* EXCHANGES VALUE *,I1,* WITH NATION *,I1
1,* FOR VALUE *,I1)
15 FORMAT (5X,I1,* SENDS *,I1,F7.0,* UNITS OF GOOD *,I1,* AND RECEIVE
IS *,F7.0,* UNITS OF GOOD *,I1)
END
SUBROUTINE DMER2 (I,N,T,IPRINT,NC)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
IT(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
```

```
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), CSPO(5), BCPO(5), FCPO(5), BCCS(5), BCBC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), A(20), B(20), C(20), D(20), TEXPR
$T(3), TIMPRT(3)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,DC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,RDPAY,GSP,VSCSCA
REAL IMPORT,IMLIM,IMBC,IMGSP
INTGER T
NW=N+1
DO 3 J=1,NW
IF (J.GT.NC) GO TO 1
TEXPRT(J)=0
TIMPRT(J)=0
1 IF (J.EQ.N+1) GO TO 2
2 EXBC(I,J)=0
IMBC(I,J)=0
IMBC(I,J)=0
EXGSP(I,J)=0
IMGSP(I,J)=0
3 CONTINUE
DO 5 J=1,N
DO 4 K=1,NC
TEXPRT(K)=TEXPRT(K)+EXPORT(I,J,K)
TXPORT(I,K)=TEXPRT(K)*GR(I,K)
TIMPRT(K)=TIMPRT(K)+IMPORT(I,J,K)
TMPORT(I,K)=TIMPRT(K)*GR(I,K)
EXBC(I,J)=EXBC(I,J)+EXPORT(I,J,K)
```

```
IMBC(I,J)=IMBC(I,J)+IMPORT(I,J,K)
EXGSP(I,J)=EXGSP(I,J)+EXPORT(I,J,K)*GR(I,K)
IMGSP(I,J)=IMGSP(I,J)+EXPORT(J,I,K)*GR(J,K)
4 CONTINUE
EXBC(I,6)=EXBC(I,6)+EXBC(I,J)
IMBC(I,6)=IMBC(I,6)+IMBC(I,J)
EXGSP(I,6)=EXGSP(I,6)+EXGSP(I,J)
IMGSP(I,6)=IMGSP(I,6)+IMGSP(I,J)
5 CONTINUE
IF (IPRINT.EQ.1) PRINT 20, I
A(1)=CSP(I,T)+TEXPRT(1)/TBC(I,T)-TIMPRT(1)/TBC(I,T)
A(2)=BCP(I,T)+TEXPRT(2)/TBC(I,T)-TIMPRT(2)/TBC(I,T)
A(3)=FCP(I,T)+TEXPRT(3)/TBC(I,T)-TIMPRT(3)/TBC(I,T)
TOTP=0
DO 6 J=1,NC
IF (A(J).LE.0) A(J)=0
TOTP=TOTP+A(J)
6 CONTINUE
IF (TOTP.LE.1.) GO TO 10
IF (IPRINT.NE.1) GO TO 7
PRINT 36, I
PRINT 37, (A(J),J=1,NC)
7 TOTP=0
EXCEPT=0
DO 8 J=1,NC
TOTP=TOTP+W(J)*A(J)
IF W(J).EQ.0) EXCEPT=A(J)
IF (EXCEPT.GT.1.) EXCEPT=1.0
8 CONTINUE
IF (IPRINT.EQ.1) PRINT 35, (W(J),J=1,NC)
DO 9 J=1,3
IF (W(J).EQ.0) GO TO 9
A(J)=(A(J)*W(J))/TOTP*(1.0-EXCEPT)
9 CONTINUE
IF (IPRINT.EQ.1) PRINT 29, (A(J),J=1,NC)
```

```
      F1=0
      GO TO 11
   10 F1=1.-TOTP
   11 DO 12 J=1,NC
      A(J+6)=TXPRT(J)/TBC(I,T)
      A(J+9)=TIMPRT(J)/TBC(I,T)
      A(J+3)=A(J+6)-A(J+9)
      A(J+12)=A(J)-A(J+3)
      DO 12 K=3,15,3
      L=K-3
      B(J+L)=A(J+L)*TBC(I,T)
   12 CONTINUE
      CSPO(I)=A(1)
      BCPO(I)=A(2)
      FCPO(I)=A(3)
      BCCS(I)=B(1)
      BCBC(I)=B(2)
      BCFC(I)=B(3)
      TPROD=0
      DO 13 J=1,NC
      C(J)=A(J)*TBC(I,T)*GR(I,J)
      C(J+6)=TXPRT(J)*GR(I,J)
      C(J+9)=TIMPRT(J)*GR(I,J)
      C(J+3)=C(J+6)-C(J+9)
      C(J+12)=C(J)-C(J+3)
      TPROD=TPROD+C(J+12)
   13 CONTINUE
      DO 14 J=1,15
      D(J)=C(J)/TPROD
   14 CONTINUE
      IF (IPRINT.NE.1) GO TO 16
      PRINT 21
      DO 15 J=1,NC
      IF (J.EQ.2) PRINT 22
      IF (J.EQ.3) PRINT 23
      PRINT 24, C(J),D(J),B(J),A(J)
```

```
PRINT 25, C(J+3),D(J+3),B(J+3),A(J+3)
PRINT 26, C(J+6),D(J+6),B(J+6),A(J+6)
PRINT 27, C(J+9),D(J+9),B(J+9),A(J+9)
PRINT 28, C(J+12),D(J+12),B(J+12),A(J+12)
15 CONTINUE
16 CONTINUE
IF (IPRINT.EQ.1) PRINT 38
A1=CSP(I,T)*TBC(I,T)*GR(I,1)
A2=BCP(I,T)*TBC(I,T)*GR(I,2)
A3=FCP(I,T)*TBC(I,T)*GR(I,3)
B1=A1-C(13)
B2=A2-C(14)
B3=A3-C(15)
IF (IPRINT.EQ.1) PRINT 30, A1,A2,A3
IF (IPRINT.EQ.1) PRINT 31, C(13),C(14),C(15)
IF (IPRINT.EQ.1) PRINT 32, B1,B2,B3
IF (LEAD(I).EQ.1) GO TO 19
DO 18 J=1,N
DO 17 K=1,NC
AIDCUE(I,J,K)=0
17 CONTINUE
IF (LEAD(J)*ALLY(I,J).NE.1) GO TO 18
IF (B1.GT.0) AIDCUE(I,J,1)=B1
IF (B2.GT.0) AIDCUE(I,J,2)=B2
IF (B3.GT.0) AIDCUE(I,J,3)=B3
IL=J
18 CONTINUE
IF (IPRINT.EQ.1) PRINT 33, IL,(AIDCUE(I,IL,K),K=1,NC)
19 CSP(I,T)=A(13)
BCP(I,T)=A(14)
FCP(I,T)=A(15)
CS(I)=C(13)
BC(I)=C(14)
FC(I)=C(15)
SURPLS(I)=F1*TBC(I,T)
IF (IPRINT.EQ.1) PRINT 34, I,SURPLS(I)
```

```
RETURN
C
C
20 FORMAT (1H1,////10X,*INTERMEDIATE DECISIONS FOR NATION*,I2)
21 FORMAT (1H0,20X,15H* CONSUMPTION *//21X,4(*VALUE IN  *)/22X,*CS*,6
1X,*P/C GSP*,5X,*NBC*,5X,*P/C TBC*)
22 FORMAT (1H0,20X,15H* INVESTMENT  *//21X,4(*VALUE IN  *)/22X,*BC*,6
1X,*P/C GSP*,5X,*NBC*,5X,*P/C TBC*)
23 FORMAT (1H0,20X,15H* GOVERNMENT  *//21X,4(*VALUE IN  *)/22X,*FC*,6
1X,*P/C GSP*,5X,*NBC*,5X,*P/C TBC*)
24 FORMAT (1X,*TOTAL PRODUCT*,2X,2(F10.1,F10.4))
25 FORMAT (1X,*NET EXPORTS*,4X,2(F10.1,F10.4))
26 FORMAT (5X,*EXPORTS*,4X,2(F10.1,F10.4))
27 FORMAT (5X,*IMPORTS*,4X,2(F10.1,F10.4))
28 FORMAT (1X,*REMAINING*/1X,*NET PRODUCT*,4X,2(F10.1,F10.4))
29 FORMAT (1X,*AFTER*,8X,3(F7.3,7X))
30 FORMAT (6X,*DESIRED LEVEL  *,3F10.1)
31 FORMAT (6X,*REALIZED LEVEL *,3F10.1)
32 FORMAT (6X,*DEFICIT        *,3F10.1)
33 FORMAT (1H0,//10X,*AID REQUEST DIRECTED TO NATION *,I1//5X,F10.1,*
1 CS*,F10.1,* BC*,F10.1,* FC*)
34 FORMAT (1H0,*SURPLUS FOR NATION*,12,5X,F10.1)
35 FORMAT (1X,*WEIGHTS*,5X,3(F7.3,7X))
36 FORMAT (1H0,*BUDGET CRISIS IN *,12/6X,* P/C  TBC*,3X,*CS*,12X,*BC*
1,12X,*FC*)
37 FORMAT (1X,*BEFORE*,7X,3(F7.3,7X))
38 FORMAT (1H0,//25X,*EVALUATION*/23X,*CS*,8X,*BC*,8X,*FC*)
END
SUBROUTINE DMER3 (I,T,N,NC,IPRINT)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
1T(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
```

```
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), CSPO(5), BCPO(5), FCPO(5), FCCS(5), FCPC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), AIDREQ(5), TF(5), DAT1(20), DAT2(
$20), CORR(5), TAID(5)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,FDPAY,GSP,VSCSCA
REAL IMPORT,IMLIM,IMBC,IMGSP
INTEGER T
IF (LEAD(I).EQ.0) GO TO 16
IF ((SURPLS(I).LE.0).AND.(IPRINT.EQ.1)) PRINT 28
IF (SURPLS(I).LE.0) GO TO 13
ADEREQ=0
DO 2 J=1,N
IF (I.EQ.J) GO TO 2
IF (ALLY(I,J).EQ.0) GO TO 2
AIDREQ(J)=0
DO 1 K=1,NC
AIDREQ(J)=AIDREQ(J)+AIDCUE(J,I,K)/GR(I,K)
1 CONTINUE
IF (IPRINT.EQ.1) PRINT 29, I,AIDREQ(J),J
ADEREQ=ADEREQ+AIDREQ(J)
2 CONTINUE
IF (IPRINT.EQ.1) PRINT 30, I,ADEREQ,SURPLS(I)
IF (ADEREQ.LE.0) GO TO 15
IF (ADEREQ.LE.SURPLS(I)) GO TO 11
SCOR=0
DO 6 J=1,N
WATRAD=0
IF (I.EQ.J) GO TO 6
DO 3 K=1,T
DO 3 L=1,N
WATRAD=WATRAD+TRADE(J,L,K)
```

```
3 CONTINUE
IF (AIDREQ(J)*ALLY(I,J).LE.0) GO TO 6
BUTRAD=0
TF(J)=0
DO 4 K=1,T
BUTRAD=BUTRAD+TRADE(J,I,K)
DAT1(K)=TFC(I,K)
DAT2(K)=TFC(J,K)
4 CONTINUE
CALL CORREL (T-1,COR,DAT1,DAT2)
CORR(J)=(COR+1.)/2.
SCOR=SCOR+CORR(J)
IF (IPRINT.EQ.1) PRINT 31, J,CORR(J)
IF (IPRINT.EQ.1) PRINT 42, BUTRAD,WATRAD
IF (WATRAD.EQ.0) GO TO 5
TF(J)=BUTRAD/WATRAD
IF (IPRINT.EQ.1) PRINT 32, J,TF(J)
GO TO 6
5 TF(J)=(-0.)
6 CONTINUE
ZTOT=0
DO 7 J=1,N
IF (I.EQ.J) GO TO 7
IF (AIDREQ(J)*ALLY(I,J).LE.0) GO TO 7
CO=0
IF (SCOR.GT.0) CO=CORR(J)/SCOR
ZTOT=ZTOT+AIDREQ(J)/ADEREQ+CO+TF(J)
7 CONTINUE
DO 10 J=1,N
IF (I.EQ.J) GO TO 10
IF (AIDREQ(J)*ALLY(I,J).LE.0) GO TO 10
R=1.
IF (TF(J).EQ.(-0.)) R=0
CORRAL=0
IF (SCOR.GT.0) CORRAL=CORR(J)/SCOR
TAID(J)=(((AIDREQ(J)/ADEREQ+CORRAL+TF(J))/(2.+R))/(ZTOT/(2.+R)))*S
```

```
1URPLS(I)
EXBC(I,J)=EXBC(I,J)+TAID(J)
EXBC(I,6)=EXBC(I,6)+TAID(J)
IF (IPRINT.EQ.1) PRINT 33, J,TAID(J)
TC=0
DO 8 K=1,NC
TC=TC+AIDCUE(J,I,K)/GR(I,K)
8 CONTINUE
DO 9 K=1,NC
TD=(AIDCUE(J,I,K)/GR(I,K))/TC
AIDCUE(J,I,K)=TAID(J)*TD*GR(I,K)
EXGSP(I,J)=EXGSP(I,J)+AIDCUE(J,I,K)
EXGSP(I,6)=EXGSP(I,6)+AIDCUE(J,I,K)
IF (IPRINT.EQ.1) PRINT 34, J,K,AIDCUE(J,I,K)
9 CONTINUE
10 CONTINUE
SURPLS(I)=0
GO TO 15
11 DO 12 J=1,N
DO 12 K=1,NC
IF (I.EQ.J) GO TO 12
IF (AIDCUE(J,I,K)*ALLY(I,J).LE.0) GO TO 12
SURPLS(I)=SURPLS(I)-AIDCUE(J,I,K)/GR(I,K)
EXGSP(I,J)=EXGSP(I,J)+AIDCUE(J,I,K)
EXGSP(I,6)=EXGSP(I,6)+AIDCUE(J,I,K)
EXBC(I,J)=EXBC(I,J)+AIDCUE(J,I,K)/GR(I,K)
EXBC(I,6)=EXBC(I,6)+AIDCUE(J,I,K)/GR(I,K)
12 CONTINUE
IF (IPRINT.EQ.1) PRINT 41
GO TO 15
13 DO 14 J=1,N
DO 14 K=1,NC
AIDCUE(J,I,K)=0
14 CONTINUE
15 CONTINUE
IF (IPRINT.EQ.1) PRINT 35, I,SURPLS(I)
```

```
GO TO 19
16 CONTINUE
IF (IPRINT.EQ.1) PRINT 36, I
IF (IPRINT.EQ.1) PRINT 37, CS(I),BC(I),FC(I)
DO 18 J=1,N
IF (ALLY(I,J)*LEAD(J).NE.1) GO TO 17
CS(I)=CS(I)+AIDCUE(I,J,1)
BC(I)=BC(I)+AIDCUE(I,J,2)
FC(I)=FC(I)+AIDCUE(I,J,3)
IF (IPRINT.EQ.1) PRINT 38, (AIDCUE(I,J,K),K=1,NC)
17 DO 18 K=1,NC
IMBC(I,J)=IMBC(I,J)+AIDCUE(I,J,K)/GR(I,K)
IMBC(I,6)=IMBC(I,6)+AIDCUE(I,J,K)/GR(I,K)
IMGSP(I,J)=IMGSP(I,J)+AIDCUE(I,J,K)
IMGSP(I,6)=IMGSP(I,6)+AIDCUE(I,J,K)
AIDCUE(I,J,K)=0
18 CONTINUE
IF (IPRINT.EQ.1) PRINT 39, CS(I),BC(I),FC(I)
CSP(I,T)=(CS(I)/GR(I,1))/TBC(I,T)
BCP(I,T)=(BC(I)/GR(I,2))/TBC(I,T)
FCP(I,T)=(FC(I)/GR(I,3))/TBC(I,T)
IF(IPRINT.EQ.1) PRINT 40, CSP(I,T),BCP(I,T),FCP(I,T)
HOST(I,6,T+1)=0
19 DO 20 K=1,T
DATUM(K)=TFC(I,K)
20 CONTINUE
IRS=IRSSUP(I)
CALL FORCST (T,EST,IRS)
TFC(I,T+1)=EST
DO 24 J=1,N
IF (J.EQ.1) GO TO 24
DO 21 K=1,T
DATUM(K)=TFC(J,K)
21 CONTINUE
IRS=IRSSUP(I)
CALL FORCST (T,EST,IRS)
```

```
TFC(J,T+1)=EST
FSUM=TFC(I,T+1)+TFC(J,T+1)
FDIF=TFC(I,T+1)-TFC(J,T+1)
IF (FSUM.EQ.0) FSUM=1.0
IF (FSUM.EQ.0) FDIF=0
DO 22 K=1,T
DATUM(K)=HOST(J,I,K)
22 CONTINUE
IRS=IRSSUP(I)
CALL FORCST (T,EST,IRS)
FTRADE=0
IF (IMBC(I,6).LE.0) GO TO 23
FTRADE=IMBC(I,J)/IMBC(I,6)
23 CONTINUE
HOST(I,J,T+1)=PAR(13)*EST-PAR(14)*(FDIF/FSUM)-PAR(15)*ALLY(I,J)+PA
1R(17)*FTRADE
IF (HOST(I,J,T+1).LT.0) HOST(I,J,T+1)=0
HOST(I,6,T+1)=HOST(I,6,T+1)+HOST(I,J,T+1)
24 CONTINUE
IF (SURPLS(I).LE.0) GO TO 25
IF (IPRINT.EQ.1) PRINT 26, CS(I),BC(I),FC(I)
AZZZ=CSP(I,T)+BCP(I,T)+FCP(I,T)
CS(I)=CS(I)+(CSP(I,T)/AZZZ)*SURPLS(I)
BC(I)=BC(I)+(BCP(I,T)/AZZZ)*SURPLS(I)
FC(I)=FC(I)+(FCP(I,T)/AZZZ)*SURPLS(I)
CSP(I,T)=CS(I)/(TBC(I,T)*GR(I,1))
BCP(I,T)=BC(I)/(TBC(I,T)*GR(I,2))
FCP(I,T)=FC(I)/(TBC(I,T)*GR(I,3))
IF (IPRINT.EQ.1) PRINT 27, CS(I),BC(I),FC(I)
25 CONTINUE
RETURN
C
C
26 FORMAT (1H0,10X,*DISTRIBUTION OF SURPLUS*/11X,*CS*,10X,*BC*,10X,*F
1C*/1X,*BEFORE*3(F10.1,2X))
27 FORMAT (1X,*AFTER *,3(F10.1,2X))
```

```
28 FORMAT (1H0,* NO SURPLUS-NO AID GIVEN*)
29 FORMAT (1H0,* NATION*,I2,* RECEIVED AID REQUEST OF *,F10.1,*BC FRO
1M*,I2)
30 FORMAT (1H0,*TOTAL AID REQUEST FOR *,I2,3X,F10.1,* BC*/1X,* SURPL
1US =*,F10.1)
31 FORMAT (1H0,*COHESIVENESS MEASURE FOR NATION*,I2,5X,F10.4)
32 FORMAT (1H0,*MARKET SHARE FOR NATION*,I2,5X,F10.4)
33 FORMAT (1H0,*TOTAL AID IN NBC THAT*,I2,* WILL RECEIVE *,F10.1)
34 FORMAT (1X,*AID IN GOOD*,I2,* THAT *,I2,* WILL RECEIVE*,F10.1)
35 FORMAT (1H0,*NATION*,I2,* FINAL SURPLUS =*,F10.1)
36 FORMAT (1H0,///1X,*REVIVED NATIONAL ACCOUNT FOR*,I2//19X,*CS*,8X,*
1BC*,8X,*FC*)
37 FORMAT (3X,*BEFORE AID   *,3F10.1)
38 FORMAT (3X,*AID RECEIVED *,3F10.1)
39 FORMAT (3X,*AFTER AID    *,3F10.1)
40 FORMAT (3X,*FINAL*/3X,*3/C TBC*,6X,3F10.4)
41 FORMAT (1H0,*ALL AID REQUEST FILLED*)
42 FORMAT (1X,*BUTRAD(TOTAL)=*,F10.1/1X,*WATRAD(TOTAL)=*,F10.1)
END
SUBROUTINE CORREL (N,CORR,DAT1,DAT2)
DIMENSION DAT1(20), DAT2(20)
IF (N.LE.3) GO TO 2
SDATX=0
SDATX2=0
SDATY=0
SDATY2=0
SDATXY=0
DO 1 I=1,N
SDATX=SDATX+DAT1(I)
SDATX2=SDATX2+DAT1(I)**2
SDATY=SDATY+DAT2(I)
SDATY2=SDATY2+DAT2(I)**2
SDATXY=SDATXY+DAT1(I)*DAT2(I)
1 CONTINUE
AN=N
CORR=(AN*SDATXY-SDATX*SDATY)/SQRT((AN*SDATX2-SDATX**2)*(AN*SDATY2-
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```
1SDATY**2))
RETURN
2 CORR=1.0
RETURN
END
SUBROUTINE CALCER (N,T,INSWIN)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
1T(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12) PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), CSPO(5), BCPO(5), FCPO(5), BCCS(5), BCBC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), CSMIN(5), VSCSCA(5,12), POW(10),
$DDLF(10), DDL(10)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,RDPAY,GSP,CSMIN,VSCSCA
REAL IMPORT,IMLIM,IMBC,IMGSP
INTEGER T
DO 5 I=1,N
GSP(I)=CS(I)+BC(I)+FC(I)
CSMAX=TBC(I,T)*GR(I,1)
IF (INSWIN.EQ.1) GO TO 1
CSM=CSMAX*(1.-CSMAX/380000.)
VSCS(I)=INT(1.5+55.*(CS(I)/CSM-1.)-41.*CSMIN/CSMAX*(CS(I)/CSM-1.)*
1*2)
GO TO 4
1 IF (CSMAX.LT.VSCSCA(1,1)) IZ=0
DO 2 IQ=1,4
IF ((CSMAX.GT.VSCSCA(IQ,1)).AND.(CSMAX.LT.VSCSCA(IQ+1,1))) IZ=IQ+1
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```
2 CONTINUE
IF (CSP(I,T).LT.VSCSCA(IZ,2)) VSCS(I)=0
DO 3 IM=3,12
IF ((CSP(I,T).GT.VSCSCA(IZ,IM-1)).AND.(CSP(I,T).LT.VSCSCA(IZ,IM)))
1 VSCS(I)=IM-2
3 CONTINUE
4 CONTINUE
DDL(I)=DDLC(I)+DDLV(I)
IF (DDL(I).GT.1.) DDL(I)=1.
DDLF(I)=0
IF ((DDLC(I).EQ.1.).AND.(DDLV(I).EQ.0)) DDLF(I)=1.
IF ((DDLC(I).EQ.1.).AND.(DDLV(I).EQ.(-1.))) DDLF(I)=2.
IF (DL(I,T).GE.8.) DDLF(I)=2.*DDLF(I)
DL(I,T+1)=DL(I,T)+DDL(I)
IF (DL(I,T+1).GT.10.) DL(I,T+1)=10.
IF (DL(I,T+1).LT.1.) DL(I,T+1)=1.
DEP=.05
Y=RANF(X)
IF (Y.GT..66) DEP=.1
IF (Y.LT..34) DEP=.02
TBC(I,T+1)=TBC(I,T)+BC(I)-.04*DDLF(I)*TBC(I,T)-DEP*TBC(I,T)
DP=.3
Y=RANF(X)
IF (Y.GT..66) DP=.4
IF (Y.LT..34) DP=.2
TFC(I,T+1)=TFC(I,T)+FC(I)-DP*TFC(I,T)-.1*DDLF(I)*TFC(I,T)
POW(I)=(1.-FICP(I,T))*TFC(I,T+1)+.5*TBC(I,T+1)
5 CONTINUE
DO 7 I=1,N
ALPOW=0
OPPOW=0
DO 6 J=1,N
ALPOW=ALLY(I,J)*POW(J)+ALPOW
OPPOW=ABC(ALLY(I,J)-1.)*POW(J)+OPPOW
6 CONTINUE
VSNS(I)=3.*ALPOW/OPPOW+1.3
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IF ((ALPOW/OPPOW).LT..37) VSNS(I)=VSCS(I)
IF (VSNS(I).GT.10.) VSNS(I)=10.
7 CONTINUE
DO 11 I=1,N
VSM(I,T+1)=.5*VSCS(I)+.5*VSNS(I)-DDLF(I)+2.*WAR(I)+2.*REV(I,T)+REV
1(I,T-1)
POH(I,T+1)=.01*(11.-DL(I,T+1))*VSM(I,T+1)+.1*(DL(I,T+1)-1.)
PSR=1.-FICP(I,T)
PR(I,T+1)=(.1*DL(I,T+1)+PSR)/2.
IF (VSM(I,T+1).GT.3.) PR(I,T+1)=0
REV(I,T+1)=0
IF (RANF(X).LT.PR (I,T+1)) REV(I,T+1)=1.
TBC(I,T+1)=TBC(I,T+1)-.2*REV(I,T+1)*TBC(I,T+1)
IF (TBC(I,T+1).LT.0) TBC(I,T+1)=(-0)
IF (TBC(I,T).LE.0) PDTBC(I,T+1)=0
IF (TBC(I,T).LE.0) GO TO 8
PDTBC(I,T+1)=TBC(I,T+1)/TBC(I,T)-1.
8 CONTINUE
RDPAY(I)=0
TFC(I,T+1)=TFC(I,T+1)-FICP(I,T)*REV(I,T+1)*TFC(I,T+1)
IF (TFC(I,T+1).LT.0) TFC(I,T+1)=(-0)
IF (TFC(I,T).LE.0) PDTFC(I,T+1)=0
IF (TFC(I,T).LE.0) GO TO 9
PDTFC(I,T+1)=TFC(I,T+1)/TFC(I,T)-1.
9 IF (INSWIN.EQ.1) GO TO 10
CSMIN(I)=TBC(I,T+1)*GR(I,1)*(1.-((TBC(I,T+1)*GR(I,1))/380000.))
GO TO 11
10 CSMAX=TBC(I,T+1)*GR(I,1)
CSMIN(I)=.9*CSMAX
IF(CSMAX.GT.38000.) CSMIN(I)=.8*CSMAX
IF(CSMAX.GT.76000.) CSMIN(I)=.7*CSMAX
IF(CSMAX.GT.114000.) CSMIN(I)=.6*CSMAX
IF(CSMAX.GT.152000.) CSMIN(I)=.5*CSMAX
11 CONTINUE
RETURN
END
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SUBROUTINE OUTPUT (I,T,IRUN,ITAPE,IPRINT,IRTAPE)
DIMENSION DATUM(20), GR(10,3), EXPRC(25,3,3), EXPORT(5,5,3), IMPOR
1T(10,10,3), IMLIM(10,3), TBC(10,12), ABC(10), CSP(10,12), BCP(10,1
22), FCP(10,12), FICP(10,12), CS(10), BC(10), FC(10), DL(10,12), DD
3LC(10), WAR(10), REV(10,12), TFC(10,12), ALLY(10,10), VSM(10,12),
4POH(10,12), PR(10,12), POHM(10), PDTBC(10,12), PDTFC(10,12), ITRAN
5S(5,5), LEAD(5), TRADE(5,5,12), AID(5,5,12), ALPOH(5,12), ALGRO(5,
612), ALSEC(5,12), FCCUE(5,5), AIDCUE(5,5,3), HOST(6,6,12), CSMF(5)
7, ST(5,30), DDLV(5), IRSSUP(5), W(3), SURPLS(5), PAR(20), VSCS(10)
8, VSNS(10), TXPORT(5,3), TMPORT(5,3), EXBC(5,6), IMBC(5,6), EXGSP(
95,6), IMGSP(5,6), CSPO(5), BCPO(5), CSPO(5), BCCS(5), BCBC(5), BCF
$C(5), RDPAY(5), GSP(5), CARD(8), CSMIN(5), VSCSCA(5,12)
COMMON DATUM,GR,EXPRC,EXPORT,IMPORT,IMLIM,TBC,ABC,CSP,BCP,FCP,FICP
1,CS,BC,FC,DL,DDLC,WAR,REV,TFC,ALLY,VSM,POH,PR,POHM,PDTBC,PDTFC,ITR
2ANS,LEAD,TRADE,AID,ALPOH,ALGRO,ALSEC,FCCUE,VSCS,VSNS,PAR,HOST,CSMF
3,DDLV,IRSSUP,AIDCUE,SURPLS,W,TXPORT,TMPORT,IMGSP,EXBC,IMBC,EXGSP,C
4SPO,BCPO,FCPO,BCCS,BCBC,BCFC,RDPAY,GSP,CSMIN,VSCSCA,
REAL IMPORT,IMLIM,IMBC,IMGSP
INTEGER T
IF (IPRINT.EQ.1) PRINT 3, T
IF (IPRINT.EQ.0) GO TO 1
PRINT 4, TBC(I,T+1),TFC(I,T+1),PDTBC(I,T+1),PDTFC(I,T+1),CSMIN(I),
1RDPAY(I),DDLV(I),VSCS(I),VSNS(I),VSM(I,T+1),POH(I,T+1),DL(I,T+1),P
2R(I,T+1),REV(I,T+1),(HOST(I,J,T+1),J=1,6),CSPO(I),BCPO(I),FCPO(I),
3CSP(I,T),BCP(I,T),FCP(I,T),FICP(I,T),BCCS(I),BCBC(I),BCFC(I),CS(I)
4,BC(I),FC(I),DDLC(I),(TXPORT(I,J),J=1,3),(IMPORT(I,J),J=1,3),GSP(I
5),(EXBC(I,J),J=1,6),(IMBC(I,J),J=1,6),(EXGSP(I,J),J=1,6),(IMGSP(I,
6J),J=1,6)
1 IF (IRTAPE.EQ.0) GO TO 2
IF (ITAPE.EQ.0) GO TO 2
IDM=1000*IRUN+100*I+T+1
IDN=IDM-1
WRITE (1,5) IDM,TBC(I,T+1),TFC(I,T+1),PDTBC(I,T+1),PDTFC(I,T+1),CS
1MIN(I),RDPAY(I),DDLV(I),IDM,VSCS(I),VSNS(I),VSM(I,T+1),POH(I,T+1),
2DL(I,T+1),PR(I,T+1),REV(I,T+1),IDM,(HOST(I,J,T+1),J=1,6),IDN,CSPO(
3I),BCPO(I),FCPO(I),CSP(I,T),BCP(I,T),FCP(I,T),FICP(I,T),IDN,BCCS(I
```

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4),BCBC(I),BCFC(I),CS(I),BC(I),FC(I),DDLC(I),IDN,(TXPORT(I,J),J=1,3
5),(TMPORT(I,J),J=1,3),GSP(I),IDN,(EXBC(I,J),J=1,6),IDN,(IMBC(I,J),
6J=1,6),IDN,(EXGSP(I,J),J=1,6),IDN,(IMGSP(I,J),J=1,6),IDN
2 CONTINUE
RETURN
C
C
3 FORMAT (1H0,10X,*RESULTS FOR PERIOD *,I2/////)
4 FORMAT (1X,5X,2F10.1,2F10.4,3F10.1,4X,*1*/1X,5X,7F10.4,4X,*2*/1X,5
1X,6F10.4,14X,*3*/80X,*4*/1X,5X,7F10.4,4X,*5*/1X,5X,7F10.1,4X,*6*/1
2X,5X,7F10.1,4X,*7*/1X,5X,6F10.1,14X,*8*/1X,5X,6F10.1,14X,*9*/1X,5X
3,6F10.1,13X,*10*/1X,5X,6F10.1,13X,*11*/1X,5X,73X,*12*)
5 FORMAT (I5,2F10.1,2F10.4,3F10.1,4X,*A*/15,7F10.4,4X,*B*/15,6F10.4,
114X,*C*/79X,*D*/I5,7F10.4,4X,*E*/I5,7F10.1,4X,*F*/I5,7F10.1,4X,*G*
2/I5,6F10.1,14X,*H*/I5,6F10.1,14X,*I*/I5,6F10.1,13X,*J*/I5,6F10.1,
313X,*K*/I5,73X,*L*)
END
```

GLOSSARY

ABUFF	The amount of received hostility that a nation will ignore if its source is an ally. (59)*
AD	A non-leader's own estimate of expected threat. (39-40)
AF	The degree to which an alliance member has followed its alliance leader's suggestions concerning defense expenditures. (55-56)
AID	International assistance in the form of grants which may include consumption, investment, or defense goods. (53-56)
AIDREQ	The request made by an alliance member to its alliance leader for assistance. (56)
ALGA	The aspiration level for economic growth adaptation rate; the speed with which the growth goal will rise or fall given success or failure. (33-34)
ALGAAS	The aspiration level for economic growth adaptation asymmetry;the degree to which a nation will more readily raise its growth aspiration level given success and more reluctantly lower it given failure. (33-34)
ALGE	The aspiration level for economic growth emulation factor; the degree to which the achievement of a significant other nation with respect to economic growth will influence the nation's own growth goal. (33-34)
ALGI	The aspiration level for economic growth inertia factor; the propensity of the growth goal to remain constant given no stimulus for change. (33-34)
ALGOR	The aspiration level for economic growth operationalization rate; the rate at which closure is sought between the desired rate of growth and the current rate of growth. (44)

*Numbers in parentheses refer to the pages in Chapter II where a fuller discussion of the concept is to be found.

ALGRO The aspiration level for economic growth; the rate of growth which the nation considers desirable at a point in time. (33-34)

ALLY The relationship between nations where each is committed to assist the other in the event of an attack on one of them.

ALPA The aspiration level for political stability adaptation rate; the speed with which the political stability goal will rise or fall given success or failure. (32-33)

ALPAAS The aspiration level for political stability adaptation asymmetry; the degree to which a nation will more readily raise its political stability aspiration level given success and more reluctantly lower it given failure. (32-33)

ALPE The aspiration level for political stability emulation factor; the degree to which the achievement of a significant other nation with respect to political stability will influence the nation's own political stability goal (32-33)

ALPI The aspiration level for political stability inertia factor; the propensity of the political stability goal to remain constant given no stimulus to change. (32-33)

ALPOH The aspiration level for political stability; the desired probability that the decision-makers will retain their decision-making positions.

ALPOR The aspiration level for political stability operationalization rate; the rate at which closure is sought between the desired level of political stability and the current level of political stability. (44)

ALSEC The aspiration level for national security; the proportion of its resources a nation desires to allocate to defense needs to counter expected threat. (34-43)

ALSID The propensity for nations to discount hostile verbal statements when estimating hostile intentions. (39)

APOW The expected threat-countering capability of a leader's alliance. (38)

APPF The alliance preference pricing factor; the proportionate export price decrease or increase given allies and non-allies respectively. (48)

BC Basic capability; value which has the characteristic of being able to produce more value.

BCGR Basic capability generation rate; the basic capability value produced by the commitment of one unit of resources (TBC) to the investment sector. (13)

BCP The proportion of national resources (TBC) devoted to the investment sector for the production of BC value. (14)

CS Consumption satisfaction; value which has the characteristic of being able to satisfy population wants and needs. (12)

CSGR Consumption satisfaction generation rate; the consumption satisfaction value produced by the commitment of one unit of resources (TBC) to the consumption sector. (13)

CSmax The amount of CS value that would be produced if all national resources were devoted to the consumption sector. (17)

CSmin The minimum level of CS value production necessary to maintain the nation.(17)

CSP The proportion of national resources (TBC) devoted to the consumption sector for the production of CS value. (14)

DBC The depreciation rate for national productive resources. (14)

DFC The depreciation rate for total force capability. (14)

DL Decision latitude; the degree to which decision-makers are dependent upon validator support for their continuation as decision-makers. (20-21)

EBUFF The degree to which the expression of hostile feelings will be suppressed for the sake of maintaining close economic ties. (60)

ECAF The emergency CS allocation factor; the propensity of the regime to react to a crisis of support by acceding to the validators' wishes with an emergency CS allocation. (44)

EGPRI The national priority assigned the goal of economic growth. (53)

ESPF The economic strength pricing factor; the degree to which export prices are raised or lowered in response to differential abilities to pay. (48-49)

EXPRC The set of national export prices indicating the terms of trade for each commodity pair with each potential trade partner. (47-50)

FC Force capability; the value which has the characteristic of being able to destroy other value. (12)

FCCUE The suggestion as to level of defense expenditure which an alliance leader makes to an alliance member (36-39)

FCGR Force capability generation rate; the force capability value produced by the commitment of one unit of resource (TBC) to the defense sector. (13)

FCic The amount of total force capability (TFC) devoted to internal security. (19)

FCP The proportion of national resources (TBC) devoted to the defense sector for the production of FC value. (14)

FicP The proportion of total force capability (TFC) devoted to internal security. (45)

GR The set of national generation rates including CSGR, BCGR, and FCGR. (13)

HOST The aggregate flow of threats, accusations, and protests between nations. (56-60)

IEFCT The effectiveness of identive power to cause an alliance member to conform to its alliance leader's defense allocation suggestion. (42-43)

IMLIM The national import limit for a specific good. (46)

IP RULE 4 Information processing rule number four, the rule by which expectations as to future behavior are derived from present behavior; also referred to as the null rule. (24)

IP RULE 3 Information processing rule number three, the rule by which expectations as to future behavior are derived from the present behavior and the last change in behavior; also referred to as the incremental rule. (25)

IP RULE 2 Information processing rule number two; the rule by which expectations as to future behavior are derived by averaging past behavior; also referred to as the mean rule. (25)

IP RULE 1 Information processing rule number one; the rule by which expectations as to future behavior are derived from the detection of trends. (25-26)

IP RULE 0 Information processing rule zero; the rule which specifies the use of rules one through four depending on which rule would have yielded the best prediction had it been used in the previous period; also referred to as the pragmatic rule. (28)

IPOW Identive power; the amount of moral suasion that an alliance leader can exert over an alliance member by the manipulation of symbolic rewards. (41-43)

IRPF International risk pricing factor; the degree to which export prices are raised in response to the reception of hostile communications. (49-50)

ITAF International trade autarky factor; the propensity of a nation to import goods. (46)

NSPRI The national priority assigned the goal of maintaining national security. (53)

OPOW The expected threat that an alliance leader believes its alliance should be able to counter. (38)

PBUFF The degree to which the transmission of hostile feelings will be suppressed in response to differences in national power between actor and target. (58-59)

PDTBC The rate of growth in productive resources (TBC) from one period to the next. (44)

POH Probability of office-holding; the overall measure of the stability of the national political system. (21)

PR Probability of revolution; the degree to which the validators are organized in opposition to the decision-makers. (22-23)

PSPRI	The national priority assigned the maintenance of political stability. (53)
REACT	The propensity to react to the reception of hostility by transmitting hostility. (56-57)
SURPLUS	The amount of resources left for allocation after primary goal needs have been met. (55-56)
TAID	The total value of aid that is to be sent to another nation. (56)
TBC	Total basic capability; national resources available for the production of value. (13)
TF	The degree to which two nations are economically coupled through trade linkages. (55)
TFC	Total force capability; the amount of national force capability available for use in any given period of time. (13-14)
TOTIM	The total amount of imports that will be allowed to enter the nation in any given period. (46)
TRADE	The exchange of commodities by two nations. (45-51)
UPOW	Utilitarian power; the degree to which an alliance member is economically dependent on its alliance leader. (41)
VScs	Validator satisfaction with regard to consumption satisfaction; the degree to which validators give support to decision-makers in response to CS value flow. (18-19)
VSm	Validator satisfaction overall; the aggregate support of decision-makers by validators. (20)
VSns	Validator satisfaction with regard to national security; the degree to which validators are content with the international position of their nation. (19-20)

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