SUSTAINABILITY AND DIVERSITY OF DEVELOPMENT: TOWARD A GENERIC MODEL

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Abstract

This paper presents the generic framework for a national-level model of sustainability. The basic assumption is that there is not one model (or condition) but multiple possibilities; not one path, but a multiplicity of options. The countries of this world are diverse indeed, and the challenges facing them are both generic and idiosyncratic. In appreciation of the complexity and diversity of development, our approach is to depict underlying structural and functional linkages representing the profile of states, with the objective of exploring possible paths over time in response to structural conditions as well as policy choices.

RESEARCH IN PROGRESS

As we approach the 21st Century, many of the challenges of the 20th Century are still with us, and critical problems remain unresolved. With us is the challenge of designing viable social systems, robust economies, and methods for meeting the aspirations of peoples everywhere. Still unresolved are "best-theories" for shaping policy and "best-analysis" for gaining insights on dimensions of social viability and sustainability. Here we report on progress in ongoing research on the challenges of sustainability for the 21st Century.

Purpose and Product

This paper presents the generic framework for a national-level model of sustainability. The basic assumption is that there is not one model (or condition) but multiple possibilities; not one path, but a multiplicity of options. The countries of this world are diverse indeed, and the challenges facing them are both generic and idiosyncratic.

In appreciation of the complexity and diversity of development, our approach is to depict underlying structural and functional linkages representing the profile of states, with the objective of exploring possible paths over time in response to structural conditions as well as policy choices.

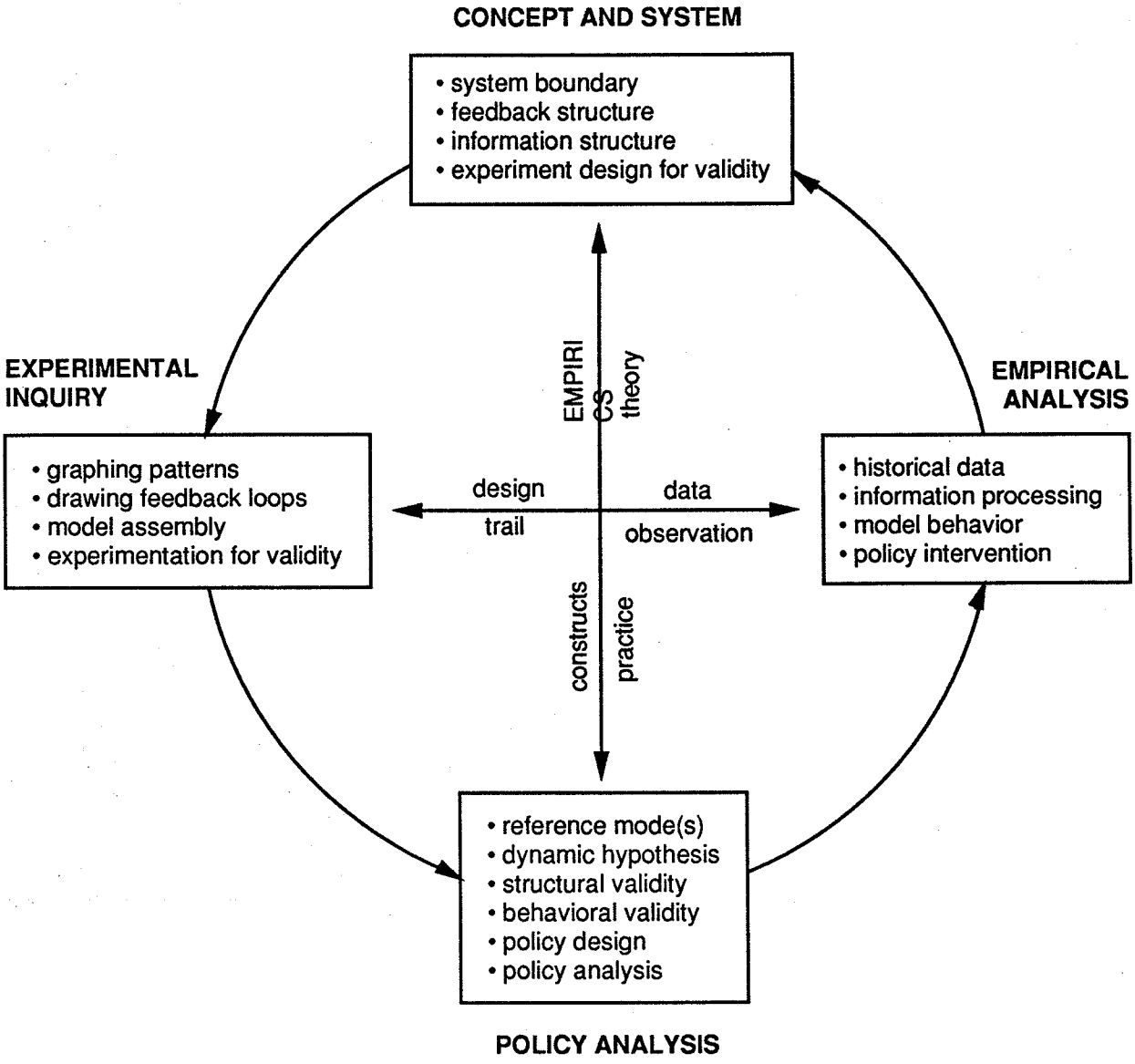
Research Strategy

Consistent with good system dynamics practice, as posited by Khalid Saeed, the research strategy pays attention to system identification, conceptualization, empirical observation, and experimentation. Adapting Saeed's directives, Figure 1 presents the key elements of learning cycles in system dynamics practice. Figure 1 shows four modules of intellectual inquiry:

- empirical analysis: to clarify properties of the empirical domain
- concept and system: to specify system focus, properties, and boundary
- experimental inquiry: to engage in "trial and error" analysis of specification
- policy analysis: to explore the "what ...if...." implications

For our purposes, these are distinct (but interactive) tasks, the combined products of which facilitate formulation and analysis of system change.

Figure 1. Modeling Development and Diversity Research Design*



* Adapted from Khalid Saeed, "The Organization of Learning in System Dynamics Practice," Working Paper # SCE/IPM/0005/94, School of Civil Engineering, Asian Institute of Technology, Bangkok, Thailand, February 1995.

DIVERSITY OF DEVELOPMENT

The Historical Record

The end of World War II led almost immediately to the termination of the imperial design and the dissolution of the great empires of the 20th Century. From the remnants grew the new nations and the new economies, which have been termed the "emergent nations." This was the phase of "nation-building"; no one was prepared for the immensity of the attendant strategic, economic, and management challenges. The past few years have seen an unprecedented rate of state-building and state-dissolution. Indeed, the last ten years or so witnessed yet another crucial and entirely unpredictable and unpredicted development, namely the dissolution of states and the creation of new nations from the remnants.

Development and Decay

Overall, then, the dynamics of the post-war period generated two modes of state-building: new states emerging from old colonial empires (i.e., controlled by Britain, France, the Netherlands, etc.) and new nations arising from the dissolution of states consolidated during the 20th Century (the USSR, Yugoslavia, etc.). Even the language of development took on new tones. We now speak once again of "emerging nations," but the context and the process of "emergence" differ fundamentally from the historical record at the close of World War II.

Over the past decade, the theory of economic development took on many shades and modes, as new explanations for "underdevelopment" were put forth and new searches for solutions were posited. One point was clear, however: the challenges of growth and development were here to stay. And one flaw in the logic was pervasive, also, and that was the erroneous presumption of identity between "growth" and "development." It took the environmental crises of the 1970s on to force a conceptual wedge between these two notions and to consolidate awareness of the dangers of "growth" in its equation to "development."

From the foregoing one generic feature of the post-war period remains unchanged, namely the diversity of development -- as a condition, a goal, a process, and an outcome.

THE SUSTAINABILITY PROBLEM

With the publication of the Brundtland Report, 1987, in response to a UN General Assembly directive to review global priorities, the notion of sustainable development was introduced in international political discourse and, over succeeding years, emerged as a contending challenger to the dominant model of development during the post-war period, namely that of economic growth.

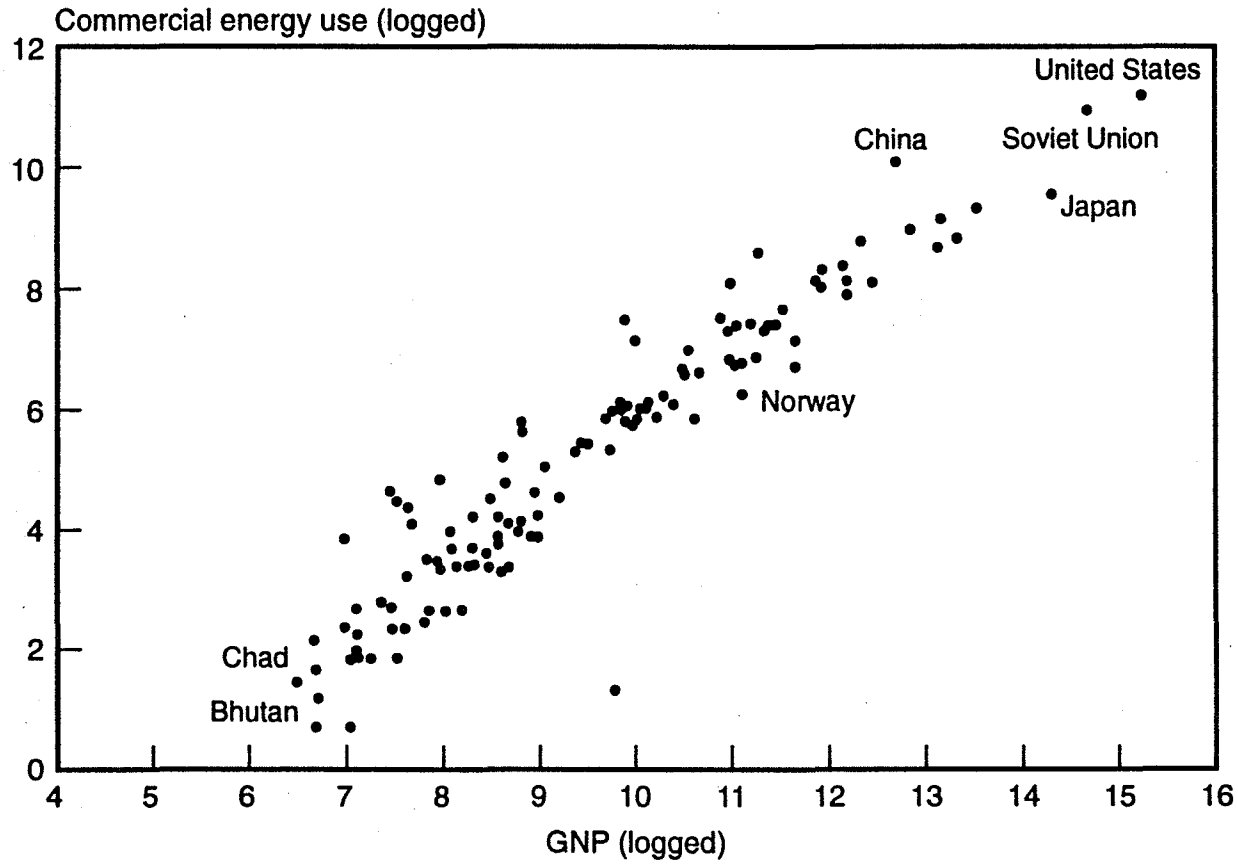
Figure 2 captures the essence of the "sustainability problem" at both national and global levels. Nationally, states are confronted by the need to meet the requirements of their citizens (through increased output, greater productivity, and "growth"). Growth invariably harbors environmental degradation (indicated in Figure 1 by trends in carbon emission). Internationally, all states are committed to continued economic performance, expansion, and growth. Globally, potential success along those lines invariably generates environmental effluence and degradation.

Environment: Imperatives

The foregoing would mean that in order for a country such as Chad to "grow" and become as powerful and strong as the United States and to do so without commensurate environmental degradation, the state would have to follow a model of development for which we have no precedent. The traditional development path is one contingent on, and interconnected with, environmental degradation.

Figure 2 summarizes two forms of comparative information: one is the sectional distribution of states of GNP/emission at one point (i.e., comparative statics, for example Chad vs. US). The other is the implied growth process over time (i.e., comparative dynamics, for example "beginning" at the Chad location and "traveling" to the US location). In the best of all positive worlds, one would wish for the GDP of the US with the carbon emission level of Chad -- an outcome beyond the realm of the possible, given present patterns of population, technology, and energy use.

Figure 2. GNP and Commercial Energy Use



Source: Nazli Choucri and Robert C. North, "Growth, Development, and Environmental Sustainability: Profiles and Paradox," in Nazli Choucri, ed., *Global Accord: Environmental Challenges and International Responses* (Cambridge, Mass.: MIT Press, 1993), p. 72. See reference for data sources.

Paths and Possibilities

The dual messages of Figure 2 -- comparative statics vs. dynamic process -- draw attention to potentials for construction of alternative paths of historical record. There may be many different ways in which a Chad could enhance the well-being of its population without emulating the historical trajectory of the industrial West, such as that of the United States.

The Brundtland Report talks of sustainable development alternatively as a condition, an outcome, and a process without differentiation. For countries seriously considering that sustainability option, it is necessary to frame what is "there" and how to get "from here to there." In analytical terms, this means identifying paths and possibilities associated with sustainability.

Growth vs. Development

Much of the ambiguities surrounding the notion of sustainability -- as a condition, process, and outcome -- can be eliminated by a clear differentiation between "growth" and "development."

As outlined by Robert C. North, growth relates to size and scale, and development relates to transformation and construction of possibilities. Far from being identical, these two terms connote fundamentally different dynamics with respect to theory, policy, and practice. It is this differentiation that provides the basic foundation for modeling the diversity of sustainability.

A MODEL OF STATE PROFILES

Basic Theory

The basic theory states that for states in the international system, differential levels and rates of change in any society's population, technology, and resource access tend to shape its "profile." By profile is meant its basic three-dimensional structure and the behavioral relations with other states that are "possible" or "probable," given its structure. To extend an earlier comparison further, a Chad is structured in ways that are different than a US (its profile is different), and its patterns of international behavior are also different.

The basic theory further postulates a set of generic profiles of nations and attendant patterns of international behavior and inter-state relations. Fundamental to the definition of profile is the disposition of three sets of variables: population, resources, and technology.

Population is viewed as an aggregate of individuals in diverse organizational contexts. Technology gives people capabilities and provides access to resources. Technology here is viewed in both organizational and mechanical terms, and resources is critical inputs (of various kinds) for human existence.

Stated thus, the basic theory is framed in static terms. But its fundamentals are dynamic. It is changes in and differentials among core variables that shape developmental trajectories and define the diversity of development experiences. And some developmental experiences are more sustainable than others. The question is which ones? how? and why? What are the implications for dynamic modeling of sustainability and the diversity of development?

Profile Definition

In large part the tasks of (a) undertaking empirical analysis and (b) defining concept and system are rooted in the definition of "national profiles." The formal definition consists of schematic interactions among population, resources, and technology, namely the core (or master) variables. As presented in Table 1, the key purpose of profile definition is to provide an internally consistent point of departure for differentiating among countries in theoretical and empirical terms. This view is static, in the sense that it captures differentiation at one point in time. And then, for any particular country (or case), the question is the extent to which developments over time maintain or alter a country's profile positioning.

Table 1. Profile Definition

Group I:	Resources	>	population	>	technology
Group II:	Population	>	resources	>	technology
Group III:	Population	>	technology	>	resources
Group IV:	Resources	>	technology	>	population
Group V:	Technology	>	resources	>	population
Group VI:	Technology	>	population	>	resources

Note: For operational purposes each group is defined as follows: Each master variable for every country is computed as a share of the global total for that variable. The variables in each group definition are thus framed in proportional relative terms, and the group profiles are in terms of relative shares. This simple method provides information about relative sizes of master variables within states and relative constraints among the master variables within states. The same information is provided across states and across profiles. With respect to indicators, we use area for resources. As an indicator of technology, we use GNP.

Source: Nazli Choucri and Robert C. North, "Growth, Development, and Environmental Sustainability: Profiles and Paradox," in Nazli Choucri, ed., *Global Accord: Environmental Challenges and International Responses* (Cambridge, Mass.: MIT Press, 1993), p. 73.

In those terms, then Profiles I and II represent the lesser developed states; and Profiles V and VI the most industrial states. Using the rule in Table 1, some empirical illustrations of countries falling in each of the profile groupings (for the year 1986) are presented in Table 2. This serves primarily to provide some "real world" reference to the challenge of articulating a generic model of developmental paths and possibilities.

Table 2. Country Profiles, 1986

Group I	Group II	Group III	Group IV	Group V	Group VI
Brazil	China	South Korea	Soviet Union	United States	Japan
Iran	India	Poland	Canada	Sweden	West Germany
Argentina	Mexico	Yugoslavia	Australia	Norway	France
South Africa	Indonesia	Portugal	Saudi Arabia	Finland	United Kingdom
Algeria	Nigeria	Hungary	New Zealand	United Arab Emirates	Italy
Venezuela	Turkey	North Korea	Libya	Iceland	Spain
Colombia	Thailand	Cuba	Oman		East Germany
Peru	Iraq	El Salvador			Netherlands
Chile	Egypt	Jamaica			Czechoslovakia
Ecuador	Pakistan	Lebanon			Romania
Cameroon	Philippines	Mauritius			Switzerland
Côte d'Ivoire	Malaysia				Belgium
Sudan	Syria				Austria
Kenya	Bangladesh				Denmark
Tanzania	Morocco				Bulgaria
Uruguay	Viet Nam				Hong Kong
Jordan	Tunisia				Greece
Zimbabwe	Guatamala				Israel
Ethiopia	Burma				Kuwait
Panama	Sri Lanka				Singapore
Zaire	Ghana				Ireland
Angola	Dominican Republic				Trinidad and Tobago
Bolivia	Yemen				
Paraguay	Costa Rica				
Gabon	Uganda				
Afghanistan	Honduras				
Mozambique	Albania				
Senegal	Nepal				
Nicaragua	Haiti				
Papua New Guinea	Rwanda				
Madagascar	Malawi				
Zambia	Sierra Leone				
Congo	Burundi				
Niger	Benin				
Guinea	Togo				
Mongolia	Lesotho				
Somalia					
Mali					
Burkina Faso					
Liberia					
Yemen, People's Democratic Republic					
Botswana					
Chad					
Central African Republic					
Mauritania					
Laos					
Bhutan					

Source: Nazli Choucri and Robert C. North, "Growth, Development, and Environmental Sustainability: Profiles and Paradox," in Nazli Choucri, ed., *Global Accord: Environmental Challenges and International Responses* (Cambridge, Mass.: MIT Press, 1993), p. 123.

Modeling State Profiles
The tradition of system dynamics modeling, initiated by Jay W. Forrester and augmented remarkably by his associates and former students, has long been recognized as pioneering systematic thinking about the dilemmas of growth and the challenges of sustainability. The "search for sustainable futures" remains an elusive and critical task.

Much of that tradition has been devoted to global level analysis, and/or to sub-national processes. Systematic cross-national and inter-temporal inquiries have been few and far between. The challenge we address is that of framing a generic model of national profiles (anchored in the basic theory and "parameterized" to different national systems). The underlying goal is to delineate emergent properties of national systems contingent on (a) interactions among the master variables that define national profiles (i.e., population, resources, technology), (b) the relationships among the master variables and the processes they engender, and (c) the dynamic evolution of the entire system over time (resulting in altering or maintaining the basic profile of the initial condition).

Model Components
The basic model consists of 7 sectors (each representing a set of interconnected causal and functional relationships). The model is "built" upon interactions among three core processes, represented in terms of sectors:

- population: generating a range of "demands," migration, and labor "supplies"
- resources: including renewable and non-renewable resources
- technology: representing conventional as well as "sustainable" technologies

And, on the basis of these interconnections, emergent properties are modeled with respect to:

- industrial performance and trade
- agricultural performance and output
- military investments and capability
- pollution and environmental degradation

Dynamic Relations
A simplified overview of the generic model is presented in Figure 3 showing key variables (population, resources, technology) and the interactions among them in terms of functional relations that engender structure.

This simplified overview obscures the interconnections among the several component-sectors of the model. Figure 4 shows the schematic format for the generic model and indicates roughly the "inputs" to, as well as "outputs" from, each sector in relation to the others.

Emergent Patterns
In this context, it is our objective to delineate system change as endogenously determined. In essence, the interaction of structure, functional relations, policy variables, and behavior possibilities serve, in principle, to generate diverse national profiles and patterns of development. Understanding (i.e., modeling) the dynamic evolution is far more difficult than designing the basic model structure.

As a first-order approximation, for experimental purposes, we should be able to generate generic profile modes from initial conditions, subject to different rates of change among the master variables and emergent functional relations.

NEXT STEPS

Reference Mode(s)
The dynamic model presented in simplified form in Figure 3 is an archetype, a generic frame, not a detailed structure. From the basic reference mode six profile-types are to be delineated. By postulating a definition of profiles, we also define the distinctive features. It is a theoretical and empirical matter (driven by necessary experimentation) to delineate the emergence of identifiable national profiles. At issue is essentially one generic reference form and six emergent and empirically observable patterns.

Figure 3. Simplified Diagram of the Generic Model

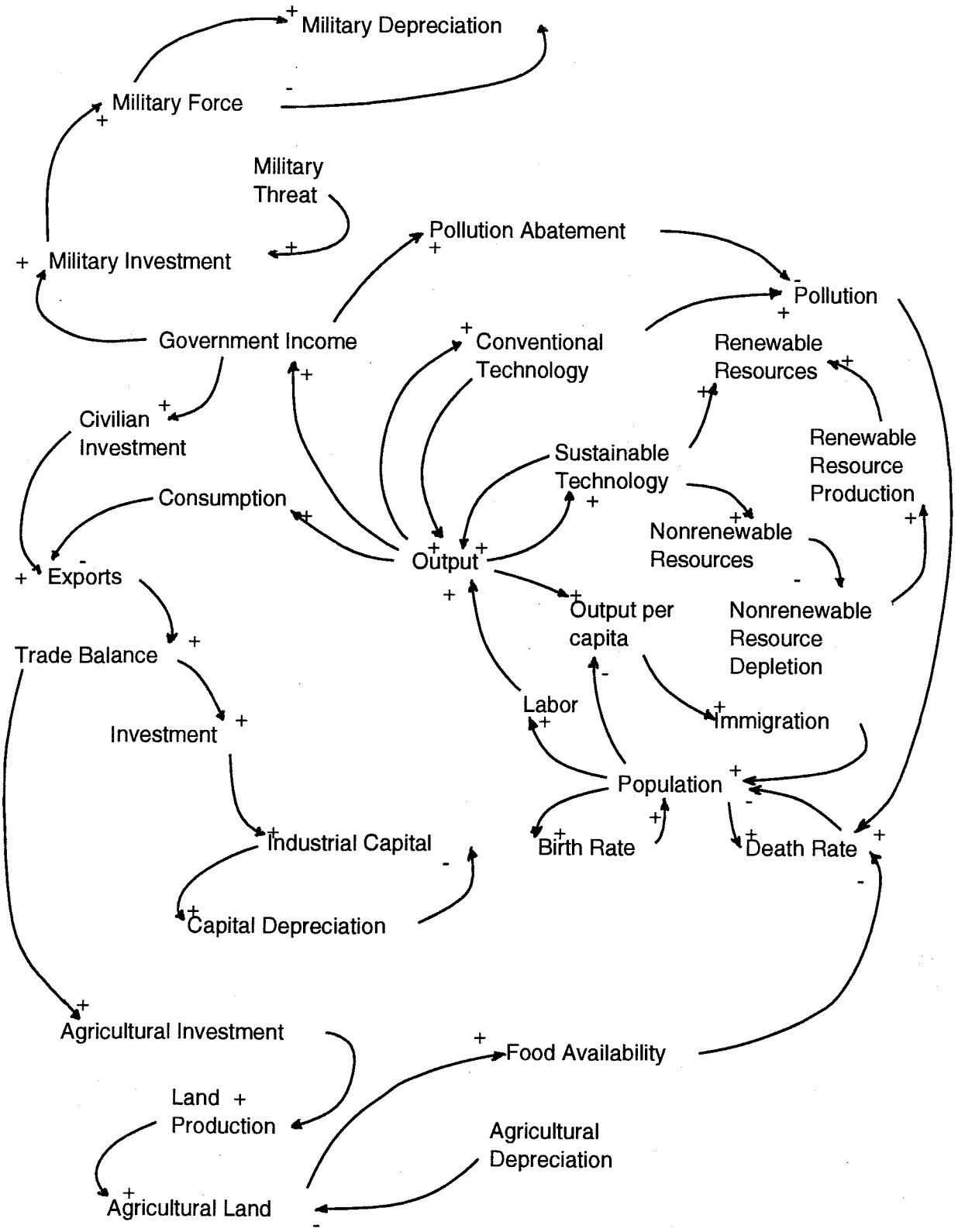
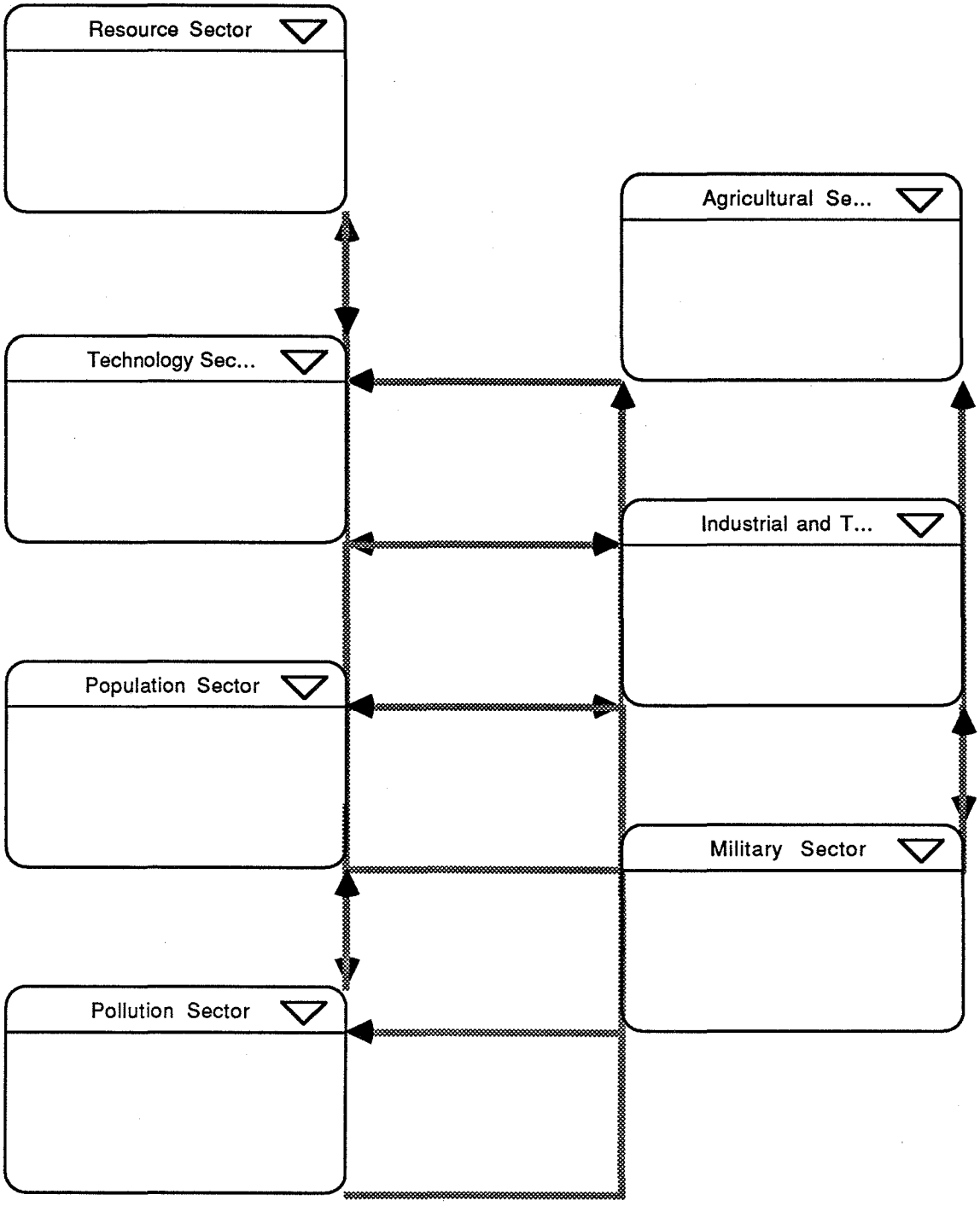


Figure 4. Schematic Format of Model Structure



Referring back to Figure 1 -- and taking into account the definitions in Table 1 -- the next step is to delineate the reference modalities consistent with the six generic profile types. This analysis is bracketed along two dimensions: one is the developmental axis (i.e., moving from a "Chad" to a "US" position on the development trajectory; specifically, this may mean "moving" along that trajectory from least-developed to most-industrialized). The other is among a diversity dimension (i.e., the variety of national-level experiences that are reflected in the distribution of countries within national profiles; for example, a "Chad" and a "China" differ in terms of scale, but they are both characterized by the same definition relationships in Table 1, namely as Group I countries.

Empirical Referents

Referring back to Figure 1 -- on good system dynamics practice -- the interaction of empirical inquiry and analytical specification is, for our purposes, essential in order to help to clarify concept and system and to help "anticipate" reasonable model behavior. This is especially critical, as the theoretical problem we are addressing pertains to diversity of development possibilities. Table 3 illustrates some of the data-based detective work based on the rules in Table 1 that must be done to better understand the historical dynamics noted in the first section of this paper.

Table 3. Illustrative Profiles: 1950-1990

Group I (R>P>T)	Group II (P>R>T)	Group III (P>T>R)	Group IV (R>T>P)	Group V (T>R>P)	Group VI (T>P>R)
Somalia, 1960-1989	China, 1968-1990	Korea, 1948-1989	USSR, 1968/69-1990	USSR, 1950-1968/69	Yugoslavia, 1963-1964/65
Saudi Arabia, 1950-c.1975	Bangladesh, 1977-1980/81	Bangladesh, 1959-1977	Saudi Arabia c.1975-1990	USA, 1967/68-1990	Yugoslavia 1976/77-1982/83
	Bangladesh, 1982-1990	Bangladesh, 1980/81-1982		Sweden, 1967/68-1990	USA, 1950-1967/68
		Yugoslavia, 1951-1963			Sweden, 1950-1967/68
		Yugoslavia, 1964/65-1976/77			Japan, 1965/66-1990
		Yugoslavia, 1982/83-1990			Germany, 1950-1990
		Japan, 1952-1965/66			

Paths and Possibilities

Essential to the next steps is a closer examination of the historical record to enable plausible delineation of system behavior along both the development and the diversity dimensions. What is "normal"? What is "sustainable"? What is "possible"? For example, a continued growth of population variables, relative to technology and economic performance -- and assuming no major advances in resource access -- will all but ensure that a country will remain in Group I. By contrast, an acceleration of technological innovations in advance of population growth -- even assuming no major change in resource access, will generate not only a profile change but also the reverberation of such changes throughout the entire system (depicted in Figures 3 and 4 above). And so forth.

Policy for Sustainability

The policy issue boils down to differentiating between what "is" to what "can be" and what "ought to be." Further, it entails "how" and with the use of which instruments or policy interventions -- when, how, and with what intended effect. Often it is the unintended effects (in terms of outcomes as well as process) that pose added challenges, sometimes beyond the pale of system structure or boundary. To the extent that both intended and unintended effects can be examined through policy analysis and experimentation (consistent with Figure 1), then the modeling task is advanced considerably. Therein lies one practical, and most important, implication of robust system design and sound system dynamics practice.