INTERNATIONAL FUTURES (IFS) MODEL

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Summary

International Futures (IFs) is a computer simulation that allows forecasts and analysis of global demographic, economic, energy, agricultural, environmental, domestic sociopolitical, and international political systems throughout the twenty-first century. Detail is available for more than 200 variables across as many as 70 different countries and regions. IFs runs under Microsoft Windows with a menu-driven structure that makes scenario analysis quite simple. The acronym IF is intended to convey the importance of developing multiple if-then scenarios about the future, rather than relying on any particular forecast.

The structures of International Futures build on the features of many of the global models developed since the early 1970s. Because IFs is inexpensively available for educational or other use (accompanying a book by the same name), it makes world modeling accessible to a wide audience.

IFs allows its users, both students and policy analysts, the ability to explore a variety of potential global transitions. Transitions in the twenty-first century need to move much of humanity to environmental sustainability and are likely to move most of humanity to social conditions that now characterize only economically advanced countries. This topic discussion uses IFs to sketch those possible changes. The model itself helps its users to investigate the sensitivity of the transitions over a wide range of assumptions about the dynamics of underlying systems and about possible policy choices.

1. International Futures (IFs) in Brief

International Futures (IFs) is a world model or computer simulation of global development that

- divides the world into geographic regions (up to 70 different countries or aggregated groupings of countries).
- represents the dynamics and interactions of demographics, economics, food systems, energy systems, selected environmental systems, and elements of domestic and international sociopolitical change.
- uses a dynamic equilibrium-seeking structure that allows simulation as far into the future as 2100.
- sits within a menu-driven modeling system that allows easy development and exploration of alternative if-then statements about the future (hence the acronym IFs).

2. History, Lineage, and Purposes

The first generation of the International Futures (IFs) simulation appeared in 1980, shortly after the publication of a review by the author of IFs of world models developed in the 1970s. Drawing upon the comparative analysis of existing world models in that book, IFs consciously integrated content and structure from several of the most widely known world models that appeared afterward, and its authors were stimulated by the pioneering world modeling of Forrester and of Dana and Dennis Meadows (the World 3 model). Specifically, IFs drew on the Mesarovic-Pestel (or World Integrated Model), the Leontief World Model, the Bariloche Foundation's world model, and the Systems Analysis Research Unit Model (SARUM) (see *World3 and Strategem: History, Goals, Assumptions, Implications* and *The World Input-Output Model*). CONDUIT, an educational software distribution center at the University of Iowa, distributed IFs in FORTRAN for use on mainframe computers.

Although the first generation of IFs was intended primarily for educational use, all generations (and especially the third, described below) have also attempted to provide policy analysis capability for specialists. For instance, the US Foreign Service Institute used the first generation of IFs in a mid-career training program, and the Central Intelligence Agency's Strategic Assessment Group has used the third generation (as has General Motors).

The second generation of International Futures was a simplified version written for microcomputer use (specifically the IBM and DOS platform) in 1985. It also targeted

educational applications, and CONDUIT again distributed it.

The third generation is a full-scale microcomputer model, and it first became available in 1993. It appeared after a prolonged period of interaction by the author with the GLOBUS modeling project at the Wissenschaftszentrum (Science Center) in Berlin. The third edition completely reworked the earlier model to improve demographic, economic, and other representations, but also to add some new content in the environmental and sociopolitical areas. It drew also upon the experience and structure of the GLOBUS model (especially the economic module), developed through the inspiration of Karl Deutsch and under the leadership of Stuart Bremer.

There have been three releases in the third generation, accompanying the first, second, or third editions, respectively, of a book also called *International Futures*:

1. The initial and substantial reworking of the original FORTRAN program, converted to QuickBasic for use under DOS on IBM-compatible platforms.
2. A second edition, converted to Visual Basic, introducing a much improved menu-driven interface, and running under Windows, which is also available for the MacIntosh (see <www.tarkvara.org>).
3. The third edition, considerably extended in content and structure. This discussion describes the third edition or release of that generation of the model (see <www.du.edu/~bhughes/ifs.html>).

In addition to the publicly available version of IFs, primarily meant for educational use, IFs is available in a Professional Edition. Although the Professional Edition incorporates a number of extensions, the primary additional feature is the ability to draw upon a database for 162 countries and to restructure the world geographically beyond the standard 14 regions to 20 regions available in the student edition (through an automated process), according to the needs of the analyst. For instance, the Professional Edition would allow focus on Indonesia, in the context of other individual ASEAN countries, all in a global setting.

3. Basic Structure of IFs

IFs has six modules: demography, agriculture, energy, economics, politics, and environment. We sketch each in turn:

1. The population model of IFs maintains 22 cohorts: infants, five-year intervals up to age 99, and those aged 100 and above (using data from the 1998 revision of the UN's population data). Overall fertility and mortality rates change in response to income, income distribution, and multipliers. The module also computes average life expectancy at birth and literacy rate, and it calculates an overall measure of the physical quality of life.
2. The agricultural model of IFs represents production, consumption, and trade of crops and meat. It represents ocean fish catch and aquaculture in less detail. It bases production on land in the categories crop, grazing, forest, urban, and "other." It represents demand for food, for livestock feed, and for industrial use of agricultural products. It is a partial equilibrium model in which food stocks buffer imbalances

between production and consumption and determine price changes.

3. The energy module portrays production of six energy types: oil, gas, coal, nuclear, hydroelectric, and other renewable sources (e.g., photovoltaic, biomass, and wood). IFs represents consumption and trade of energy in the aggregate. It represents known reserves and ultimate resources of the fossil fuels and capital costs of each energy form. It is a partial equilibrium model in which energy stocks buffer imbalances between production and consumption and determine price changes.
4. The economic module represents the economy in five sectors: agriculture, materials, energy, industry, and services. It is a general equilibrium model that does not assume exact equilibrium will exist in any given year; instead, the model chases equilibrium over time. The economic module draws on the partial equilibrium analyses from the agriculture and energy modules. International trade utilizes the "pooled" rather than the bilateral trade approach.
5. The sociopolitical module has three primary components. Within countries or geographic groupings the module represents fiscal policy—taxing and spending decisions. The categories of government spending are military, health, education, foreign aid, and a residual category. Between countries or groupings of countries, the module allows the user to explore action-reaction processes of mutual threat, which might possibly spill over into arms races with the potential for conflict among countries. Across countries, the model represents social change that typically occurs with development, including increasing democratization and greater equality for women.
6. There is also an implicit environmental module distributed throughout the overall model. It is possible, for example, to track the level of atmospheric carbon dioxide, the area of forested land, the use of fresh water, and the remaining reserves of fossil fuels.

There are various "policy handles" scattered throughout all modules for scenario analysis. For instance, in the demographic module the user can hypothesize alternate fertility rates (a government might effect those alternate rates through programs of family planning). In the agricultural module, the user can alter land-use patterns (a government could change those through tax incentives, zoning, or direct regulation). In the energy module, one can assume different capital costs in the use or production of energy (again, being affected by tax incentives or legislation). A model user invokes these policy handles by changing any of more than 200 parameters (about 70 key ones). In addition to changing individual parameters (using either time-invariant or time-specific values), it is possible to change more than 30 functional relationships within IFs by specifying analytic functions of the user's choice. IFs provides help for the development of such analytic functions. For instance, it is possible to use the modeling system of IFs to create longitudinal or cross-sectional relationships across the extensive, 162-country database that accompanies the model. Those relationships can then be taken automatically to Microsoft Excel for analysis.

IFs is a living model, and change in its structure and database continues. It therefore regularly outgrows written documentation. The extensive Help system of the model is, however, always the most accurate and up-to-date documentation for the model. That system includes not only causal-loop diagrams, but equations and model code. It further provides information on data sources, other modeling projects, and comparative

forecasts.

Those interested in the detailed documentation of the Help system can turn to either the model itself or to the IFs web site (see <www.du.edu/~bhughes/ifs.html>). In this discussion we focus on the applications of IFs.

4. Using IFs to Analyze Sustainable Development

The motivation behind development of IFs was the need for tools that allow analysis of long-term global change and human leverage with respect to that change. In particular, two issues drove the development of IFs: (1) the importance of global movement toward sustainable development and (2) the large gaps in development (economic, political, and social) between regions of the world and the need to narrow those gaps. We begin with the issue of sustainability, but will return to gaps in development.

Because of the increasing and ultimately unsustainable pressure that humanity is now placing on its environment, it is critical that humanity move significantly toward, if not completely to, sustainable patterns of development in the twenty-first century. For that reason IFs allows analysis of key demographic, agricultural, energy, economic, and environmental variables and their interaction throughout the century.

4.1. Approach to Analysis

A remarkable portion of global forecasting adopts either apocalyptic or millennial character. The Reverend Thomas Malthus helped define the apocalyptic tradition with his *Essay on the Principle of Population*, which pointed to the near inevitability of deteriorating conditions. The Club of Rome's Donella and Dennis Meadows told us that we faced imminent *Limits to Growth*.

In truly dramatic counterpoint, we can reach back to Sir Francis Bacon for an image of the *New Atlantis*. Or we can read Herman Kahn's more contemporary forecast that *The Next 200 Years* will be ones of overcoming limits, not being overcome by them, thanks to the help of Julian Simon's *Ultimate Resource*, namely people. John Naisbitt's *Megatrends* even more consistently offers promise rather than identifying problems. And Ronald Bailey tells us that *The True State of the Planet* stands in almost complete contrast to the vision of Lester Brown's *State of the World*.

Coherent but competing logics drive each of the two approaches to futurism. Each logic looks to the functioning of feedback loops in reinforcing processes. In the apocalyptic tradition, environmental and political problems can weaken the capacity of societies to adapt, thereby accelerating declines into collapses. In contrast, within the millennial tradition, technological success buttresses the ability of societies to overcome adversity, potentially transforming individual breakthroughs into periods of sustained growth.

When analysts translate one or the other of these feedback logics into consistently pessimistic or optimistic portrayals, however, they downplay the fact that both logics are almost always at work and in interaction across space, time, and issue area. With both logics always in interplay, civilizations historically have exhibited broad periods of

growth and material progress, as well as marked episodes of decay and collapse. In fact, it is the complexity of the interaction that makes predictions (especially, as is often said, about the future) untrustworthy. Not unlike the nineteenth and twentieth centuries, the twenty-first century will almost certainly be a Dickensian collage of progress and regression, of hope and despair, of good and bad times.

Analysis with IFs suggests that humanity will make progress toward sustainability in the twenty-first century. The road will, however, be a rough one, and successful completion of a transition to sustainability is improbable. In particular, we need to anticipate significant problems at the intersection of global energy and environmental systems.

IFs allows us a glance down the road into the future from two different perspectives, as if we were alternately covering each lens in a pair of eyeglasses (one reddish and the other green). First, we can examine aggregate trends in population and economics that give us a big-picture perspective on long-term human development. Second, we can shift our perspective to more specific processes occurring at a more physical level, including the specifics of agricultural, food, and environmental systems. It is apparent that many of those who have looked at human development through the first and rosier lens are quite optimistic about the future, while those who look through the second and greener lens are more skeptical. The ability of IFs to let us draw on both perspectives and the relationships between them is one of the model's special strengths. We will use each lens in turn here. It is important, however, to recognize that within IFs, these two perspectives are fully linked and interactive (like the lenses in a pair of three-dimensional glasses), and we will return to conclusions drawn from using both of our eyes.

The base case of the IFs model produced all of the figures shown here. We used Excel to polish them for presentation.

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Biographical Sketch

Dr. Hughes earned a B.S. in Mathematics from Stanford in 1967 and his Ph.D. in Political Science from the University of Minnesota in 1970. He taught at Case Western Reserve University, 1970–1980. He is now Professor at the Graduate School of International Studies, University of Denver. He also serves as the University's Vice Provost for Graduate Studies. His principal research interests are in the areas of (1) international politics, (2) computer simulation models for economic, energy, food, and population forecasting, (3) policy analysis, and (4) global futures. The fundamental concern that synthesizes these special interests is in developing effective international response to long-term global change.

Dr. Hughes has consulted for the governments of Germany, Iran, and Egypt, and for various components of the US government. He has taught courses in Costa Rica and China. He has written *The Domestic Context of American Foreign Policy* (Freeman, 1978), *World Modeling* (Lexington 1980), *World Futures* (Johns Hopkins, 1985), *Disarmament and Development* (Prentice-Hall, 1990), *Continuity and Change in World Politics* (Prentice-Hall, 1991, 1994, 1997, 2000), and *International Futures* (Westview, 1993, 1996, 1999), and numerous articles. <www.du.edu/~bhughes>