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Choices in the face of uncertainty: the international futures (IFs) model

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Abstract

The International Futures (IFs) modeling project has roots in both the world modeling projects of the 1970s (including the early Club of Rome models) and the GLOBUS modeling project of the 1980s. It has, however, added extensive capabilities for helping students and analysts think about choices in the face of uncertainty. The third edition of the *International futures* book and computer simulation have extended the analysis horizon and enhanced analysis potential, with particular focus in two areas: (1) the possible transition towards sustainability in the twenty-first century and (2) sociopolitical change within countries and in the global system. IFs is evolving from a global model to a 'global modeling system' that allows analysis of data and analytical relationships across a country-level database. This article reviews the evolution of IFs and the current model. It concludes by discussing challenging issues in the contemporary world that may be explored by students of the future using the IFs model. © 2000 Published by Elsevier Science Ltd.

1. The IFs model: lineage and evolution

International Futures (IFs) is a world model or computer simulation of long-term global development. The model has evolved since 1980 through three 'generations.' The first generation had its roots in the world models of the 1970s, including those of the Club of Rome. In particular, IFs drew on the Mesarovic–Pestel or World Integrated Model [1], the Leontief World Model [2], the Bariloche Foundation's world model [3] and the Systems Analysis Research Unit Model (SARUM) [4]. These models were all initiated at more or less the same time and as a reaction to the *Limits to growth* study. IFs was designed after a comparative analysis of those

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models by Hughes [5] primarily to be used by university students. Nonetheless, IFs has always had some policy analysis capability that has appealed to specialists. For example, the US Foreign Service Institute used the first generation of IFs in a mid-career training program.

Successive generations of IFs made use of changing computer opportunities. In particular, the second generation in 1985 moved to early microcomputers, and the third generation in 1993 became a full-scale microcomputer model. The third generation also improved earlier representations of demographic, energy, and food systems, but added new environmental and sociopolitical content, and integrated ideas from the GLOBUS model (created with the inspiration of Karl Deutsch and under the leadership of Stuart Bremer [6] at the Wissenschaftszentrum in Berlin). The third generation has produced three editions of IFs, each accompanied by a book also called *International futures* [7]. The second edition moved to a Visual Basic platform that allowed a much improved menu-driven interface, running under Windows. This article focuses, however, on the third edition.

The present model is a menu-driven modeling system that facilitates exploration of alternative scenarios or 'if–then' statements about the future (hence the acronym IFs). It represents global demographics, economics, food systems, energy systems, selected environmental systems, and elements of sociopolitical change. The student edition published with the third edition of the *International futures* book (which may be downloaded from the author's website at www.du.edu/~bhughes/IFs.html) displays the world in up to 20 geographic regions (countries or aggregated groupings of countries). The model is built on a database for 162 countries that allows cross-sectional and some longitudinal analysis of relationships among hundreds of variables. It also provides a mapping capability both for data at the country level and for forecasts at the regional level. The professional edition can represent the world with complete geographic flexibility. The IFs model uses a dynamic, equilibrium-seeking structure that makes possible simulation as far into the future as 2100.

2. Choices in the face of uncertainty

An important aspect of the IFs model is the recognition of uncertainty. If we take "what will be the future of human environmental, economic, and political–social systems in the twenty-first century?" to be our central question, then the easy and correct answer is that no-one knows. If we were so fatalistic as to believe that we had no control over the future, we might simply accept that response and return our attention to daily life. Most of us believe, however, that our actions substantially shape our own future and the futures of our descendants. Many of us fear that misguided action, whether it be environmental despoliation or nuclear war, could lead to catastrophe. Many hope that thoughtful behavior can instead assure a peaceful and prosperous world. We therefore confront a very real dilemma: we cannot know the future, but it is essential to act in the face of that uncertainty.

To reduce the dilemma to manageable proportions, we must make at least reasonable estimates about what the future holds, with and without our action. In order to

make such estimates, we can decompose our general question about the future into three more specific ones. First, where do current changes appear to be taking us? Second, what kind of future would we prefer? Third, how much leverage do we have to bring about the future we prefer? Each of these questions is more manageable than our central question (although hardly simple), and collectively they help us grapple with the necessity of choice in the face of incomplete knowledge. The task of IFs is to assist us to investigate these three questions and thereby address the dilemma we collectively face. While we cannot know the future, we must act as if we did.

Even though we may begin our investigation using simple tools to extrapolate present trends, we soon must shift our attention to causal analysis. And, as the causal discussion of global change deepens, the question of human leverage will become quite complex. Simple projection will not suffice once secondary and tertiary consequences of actions become critical. For example, there are considerable disputes over the implications of giving food and other aid to less developed countries. Often those disputes do not center on the primary impact of aid on recipients, but instead on the secondary implications of the aid for changes in the economic and political systems of the recipients. Beyond this, they may depend even on the tertiary or third-order implications of those changes in turn upon the long-term well-being of the recipients. Such secondary and tertiary consequences make it very difficult to study issues in isolation. Everything becomes connected to everything else and tracing through consequences of action becomes messy for any analyst. One approach to overcoming that difficulty is to use computers. If we can represent these complex interactions in a computer simulation or model, we can then let the computer trace through the implications of our actions.

It is evident that the use of IFs to examine the trends is significantly different from the simple extrapolation of them. The most basic difference is that IFs is a fully integrated computer model in which changes in any part of it affect the rest of it so that IFs produces forecasts through alternative scenarios, not trends. Demographic, energy, environmental, and economic forecasts in IFs are very much interactive, even when we look at each individually. Although the results that IFs produces may be very similar to extrapolations, they will never be identical. And even quite minor changes in any of the assumptions of IFs will affect all elements of the global development system.

The demographic, economic, agricultural, and energy systems of IFs are the most developed submodules and allow the most extensive scenario analysis. The demographic module is a cohort-component population model that represents fertility and mortality dynamically. The economic module is a five-sector general equilibrium module with a Cobb–Douglas production function, a Linear Expenditure System (LES) consumption system, and inventories to buffer production and consumption over time. The agricultural and energy modules are partial equilibrium systems that replace the appropriate sector within the economic module when they are activated. The agricultural module represents land use in multiple categories and distinguishes production, consumption and trade in crops, meat, and fish. The energy module rep-

resents the production, consumption, and trade of multiple energy forms, both renewable and nonrenewable.

The third edition has added a new submodule that will become increasingly important and that few models treat. Specifically, IFs now has a basic representation of domestic social and political systems. Although that module is still simple relative to others, we explore it here in somewhat more detail.

3. Domestic social and political systems

A new feature of the current IFs model is the incorporation of recent historical data for a variety of social and political variables and of relationships to forecast some of those variables. It is common to group a wide range of phenomena under the general rubric of sociopolitical condition. We can distinguish, however, two categories of such condition. The first is individual life condition. Into this category we place life expectancy, literacy rate, fertility rate, calorie availability or nutrition level, and even access to safe water and air. The second category is social organizational condition, which includes level of democratization, the social status of women, the income distribution, and the extent of corruption in economic and political life. It is easy to overdraw the distinction between the two categories, and the lines actually blur. Access to safe water, to the medical care that supports longevity, and to the education that conveys literacy certainly require social organization as well as individual action. Similarly, the extent of democracy and of corruption depends on individual action, not just collective institutions and laws. Yet a general distinction between the two categories is apparent. We can speak of the age at death of an individual or of that individual's reading ability. We cannot speak of the democracy level for a single person or of that person's income distribution, and corruption similarly implies the interaction of at least two people.

At the beginning of the twentieth century, the average GDP per capita (at exchange rates and in 1990 US dollars) of Western European countries was only US$2899 [8], about that of the median country in the world today. The rich in those days scored considerably lower, however, on some measures of individual life condition than contemporary countries with comparable income levels. For instance, life expectancy was approximately 50 in the richest Western European countries in 1900, compared to an average life expectancy today of more than 65 in countries with a GDP per capita around US$2900. Advance in medical technology has helped even the relatively poor.

We know that literacy in Britain climbed from about 50 percent in the early nineteenth century to 81 percent in 1870, as incomes rose. By 1900 it was near universal in both Britain and the US [9]. Unfortunately, it is very difficult to obtain many measures of individual life condition for even the richest countries early in the century. Our attention to data on life condition is really a post-World War II phenomenon.

Since 1960, global life expectancy has increased from 55 to 66, the total fertility rate has dropped from 4.9 to 2.9, and food calories per capita have advanced by

about 15 percent. In low-income countries social change substantially exceeded the global rate on each of these measures and on others. Life expectancy advanced from 48 to 63 over the same period, the total fertility rate dropped from 6.1 to 3.3 births per women, calories per capita advanced by 25 percent, and literacy grew from under 30 percent to 65 percent. Social development, at least in terms of individual life condition, has been a remarkable success story.

In addition to progress on such measures of individual life condition, there has been advance on at least some measures of domestic social organization. Most notably, a 'third wave' of global democratization began running in the late 1970s and accelerated with the collapse of communism in the early 1990s. Less positively, it appears (qualitatively) that a wave of nationalist fervor has simultaneously swept the world, including wars in Azerbaijan, Armenia, Bosnia-Herzogovina, and Chechnia.

As is true for individual life condition, we have unfortunately limited long-term data on social organization. Much of what we have is insightful, but anecdotal, description rather than empirical series. For instance, in his study of the United States early in the nineteenth century, Alexis de Tocqueville [10], astute observer and prescient commentator on the human condition, recognized the youth of a global social transformation. One important aspect of what de Tocqueville identified in the United States is part of what we now call the growth of 'civil society,' the proliferation of voluntary associations for a wide range of social and economic purposes. There is every reason to believe that the phenomenon is now global. For instance, the number of nongovernmental organizations with some kind of intercountry connection has grown from 69 in 1900 to more than 40,000 today. Unfortunately, we do not have a database of such organizational proliferation at the country level.

One aspect of social organization that has received much careful attention around the world and even relatively careful measurement is the level of democratization. We know that the countries that we could call 'democratic' have varied between about 20 and 40 percent of the total independent countries in the world since 1900 and that there have been three spikes in that percentage. At the same time, the number of countries independent of colonial status has increased so markedly that the absolute number of democracies has increased from under 20 to more than 60 during the century. Because colonies were not democracies, it is safe to say that democracy has advanced.

One repeated difficulty that we must confront in modeling many aspects of social organization and change is that data are skimpy. For instance, we have little or no time series data on the status of women, but anecdotal evidence would suggest that it has improved, at least in Europe and North America. Similarly, there is practically no basis upon which to discuss change in corruption levels. Data on income and wealth distribution are also scattered. Ideally, IFs would help us look into the future concerning (1) individual social condition, (2) collective social conditions like democracy and the status of human rights for women and minority groups, and (3) the extent of nationalism and violence surrounding it. Presently, however, social representations within IFs are limited to selective variables in the first two categories.

Although further development in this portion of the model is under way, the

'dynamics' of change in these indicators is currently very simple: they are driven by the level of GDP per capita. Even so, while the relationships between GDP per capita and both individual life condition and social organization are very strong, the character of those relationships varies considerably.

In many relationships we can see a 'sweet spot' in development, so that at low but increasing levels of GDP per capita, social conditions improve rapidly, but at higher levels that improvement slows. This pattern is especially common in relationships involving individual life condition. In other relationships we see a 'steady slog' so that, across a wide range of GDP per capita, social conditions change (and generally improve at higher levels), but at a fairly consistent rate regardless of the level of GDP per capita. This pattern is quite common for social organization (as opposed to individual life condition). In other relationships we also see a 'systemic shift,' whereby the character of the relationship between GDP per capita and social condition shifts significantly over time, suggesting that social condition has improved across time regardless of GDP per capita. This obviously indicates that factors other than GDP per capita are at work in determining social condition. In particular, we might suspect that technological change would improve some individual life conditions (like life expectancy), regardless of GDP per capita. Similarly, there may be global changes in ideas or culture (in critical global regimes) that are affecting aspects of social organization such as level of democracy.

Systemic shifts can occur regardless of whether the underlying relationship has the curvilinear form of the 'sweet spot' or the linear form of the 'steady slog.' We know, for example, that past waves of democracy have crested and fallen, so that it is possible that a 'systemic shift' in the opposite direction could occur in the next two decades. The 'systemic shifts,' in particular, suggest the uncertainty that we have with respect to the dynamics of sociopolitical change. Although it is difficult to predict how social organization, technology, or ideas may change underlying relationships, students and other analysts can now use the historical database and basic relationships of IFs to explore hypotheses about the relationships linking GDP per capita and social condition.

4. The interaction of choices: using IFs to explore preferred futures

This paper began by defining a dilemma that is fundamental to the philosophy behind the development and use of IFs: we cannot know the future; yet that future is terribly important to us, and we must therefore act in the face of uncertainty as if we did understand the consequences of our actions. The IFs model allows us to engage in our own experimentation with human intervention and to undertake our own assessment of the extent of human leverage, and of secondary and tertiary consequences. Exploration of our current world poses a host of challenging questions that may be addressed to 'students of the future,' many of which may be explored using the IFs model. In terms of international political futures and systemic power distributions, do you anticipate an interim period of multipolarity, of renewed bipolarity, or of US hegemony? In terms of domestic political and social development do you

foresee more democracy or its reversal? Do you anticipate progress throughout the world in terms of literacy, life expectancy, and other social variables, or deterioration in such conditions? In terms of economics, do you anticipate strengthening of free trade, perhaps led by the World Trade Organization, a struggle simply to maintain the gains of recent years, or a movement of the world to trade blocs? Would the world be better served if the globalization of trade and financial flows was reversed or if it was extended? In terms of the environment, do you foresee increased environmental destruction or the technological redress of multiple environmental problems? Do you prescribe substantial global environmental regulation, country-specific approaches, or sponsorship of technological advance? Will food and energy be adequate or will prices rise sharply and supply disruptions arise? How might agricultural and energy futures affect the development of key countries such as China and Russia?

Although IFs will assist us in better addressing these questions, it is no crystal ball. Even with the best of computer simulations, the future remains essentially unpredictable. Some bold predictions will inevitably be correct, whether based on astrology or on computer simulation. A few of those based on computer simulation may even be correct for the right reasons—they will reflect an accurate causal understanding of the way the world works. As the Danish physicist Niels Bohr put it, however, "Prediction is very difficult, especially about the future" [11].

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