

From Global to National Comprehensive Models: A Developing Country Perspective on Global Modelling in Transition

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This paper examines experience with two decades of global model-building efforts, focusing on their impact and on methodological issues. Adopting a developing country perspective, the paper then explores what may be considered as a next stage in their evolution: the development of comprehensive policy-oriented models at the national level. The models developed at GRADE in Lima, Peru are used as an illustration of what can be achieved with national comprehensive models as policy exploration tools. The paper ends with a review of the difficulties and challenges that will be faced in the transition from global to national comprehensive models.

Key words: developing countries, global models, modelling methodology, national comprehensive models, policy experimentation

A PERSPECTIVE ON GLOBAL MODELLING

The 1970s and early 1980s witnessed the emergence of global modelling as an important intellectual activity that had a significant impact on the conceptualization of contemporary problems. Starting with the well-known report *Limits to Growth*, a series of studies generated world-wide attention and stimulated lines of thought that emphasized new ideas, such as the importance of global interdependences and the need to consider the second-order environmental and resource consequences of economic activities. As Eleanora Masini¹ has pointed out, 'global models constituted the answer which science, at its level of development in the 1970s, gave to complexity, inter-relatedness and rapidity of change of society as a whole'.

These global models, together with their main characteristics, have been examined in numerous reports.^{1,2-4} This paper highlights a few issues relating to the methodology and impact of global models and, taking the point of view of developing country policy-makers and policy analysts, explores what may be considered as a next stage in their evolution.

During the last two decades, the general approach followed by most exercises aimed at examining long-term prospects for global development has involved the use of quantitative techniques to represent multiple interactions among many variables. Large-scale models dealing with the world as a whole were constructed and used in either an extrapolative or a normative mode. In the first instance, mathematical representations of the interrelations between a set of key variables (population, energy use, gross domestic product, etc.) were utilized to project long-term trends and to show their consequences. In the normative mode, models posited a series of quantitative targets and then, given the present situation as a starting-point, examined whether or not these targets were attainable. For example, the systems dynamics models used to run the simulations reported in *Limits to Growth*⁵ belong to the extrapolative category, while the models used in the report *Catastrophe or a New Society*⁶ are of a normative nature.

The lively debate that these and other reports generated focussed primarily on the structure of the mathematical equations, on the quality of the data, on the basic assumptions involved in the construction of the models, and on the results of various simulation runs. Global-modelling exercises took advantage of the rapid advances in computer technology, but became increasingly more complex and difficult to understand by the layman and even the informed reader. Accuracy and the capacity to represent more clearly complex interactions at the global level were gained at the expense of transparency and ease of understanding. There were also several studies that involved a blend of quantitative modelling and qualitative scenario-building, in which a set of variables and

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future conditions was postulated to develop alternative visions of the future. The 'Interfutures', the 'Global 2000' and the 'Globus Model' studies would belong to this category.⁷⁻⁹

From the point of view of their impact, global-modelling exercises helped to shape the international agenda of the 1970s, and were most successful in raising public awareness about world interdependences. They focussed attention on a few key issues of global importance—for example, North-South inequalities, international patterns of energy use and availability, resources management, population growth and environmental degradation—showing the complexity of the choices faced, the importance of taking into account feedbacks, and the need to consider the second-order consequences of human activities.

The global-modelling exercises of the 1970s and early 1980s were not designed to support directly on-going policy- and decision-making activities in government or private circles. Their policy impact was indirect and came primarily through the dissemination and subsequent adoption of concepts and ideas associated with the models and their results. This stands in contrast with models constructed to analyse policy options in specific issues (such as water management, energy utilization, urban growth patterns, transportation planning and agricultural land-use), for which objective functions and constraints can be more readily identified to develop policy-oriented models that have a more direct impact on decision-making.

It is worth noticing that—with the notable exception of the Bariloche Group report *Catastrophe or a New Society*—practically no global models developed in the Third World gained wide recognition or were extensively disseminated. It would appear that the concern of developing country researchers and policy-makers was more focussed on local problems, rather than on the worldwide issues that gained the attention of global modellers. As a result, while the global models of the last two decades raised many issues of great importance for the future of mankind, they did not focus on the specific policy concerns of developing countries.

With several global models now in operation² with two decades of experience in global modelling, with significant advances in microcomputer technology, and with development issues and concerns acquiring greater prominence, what are the possible directions for global model-building exercises in the next few years? Is it possible to reinterpret the concept of 'global model' in a way more relevant to the policy and decision-support needs of developing countries?

GLOBAL MODELLING IN TRANSITION

Before attempting to answer these questions, it is important to note that the widespread attention received by global models and their results has often blurred the importance of a variety of other approaches and methodologies in policy-oriented research, long-range planning and future studies.¹⁰⁻¹⁵ The emphasis placed on modelling exercises in this paper should not give the impression that futures research and the design of long-term development strategies in Third World countries should be exclusively, or even primarily, a modelling activity.

Second, during the last two decades the world has been experiencing a transition to higher levels of complexity and inter-relatedness.¹ The pace of change in the economic, political, social, cultural, scientific and technological fields has accelerated enormously and now poses challenges of unprecedented magnitude.¹⁶ As a result, the conceptual frameworks that evolved during most of the post-World War II period appear woefully inadequate to understand an ever-shifting contemporary international environment. Facing uncertainty and rapid change, policy-making at the national and regional levels in the developing world has more often than not been reduced to the adoption of a series of short-term decisions, without a vision of the future to guide them. However, these changes make it more necessary than ever continuously to explore a variety of possible future development paths, a task that can be greatly assisted by quantitative simulation techniques.

Third, it could be argued that global modelling exercises have, in the main, run their course. They were most successful and useful in creating an awareness of global interdependences; in showing the interconnections between resource availability, energy use, population growth and similar variables; in disseminating new ideas such as carrying capacity and sustainable development; and in providing a general background against which to examine the design of long-run development strategies at the country level. But after achieving these objectives—and considering

the fact that several global models are now being continuously updated—there is little that can be added by continuing to work primarily with global models of the 1970s and early 1980s vintages. However, there is much to be learned and done by building upon the philosophy, approach and methodologies developed in these exercises and applying them to other tasks.

The new challenges to model-building are likely to emerge in the design of development strategies for developing countries. This suggests the need to build on the experience accumulated in the construction and operation of global models, reinterpreting this experience in the context of comprehensive policy-oriented model-building activities for the design of national and regional long-term development strategies.

One of the most striking findings of the reviews of modelling activities in the Third World has been that, even though there are many examples of sectoral and problem-specific modelling activities, with some exceptions related primarily to training (for example, the 'Stratagem' simulation tools developed by D. Meadows and his colleagues), mathematical models have not been widely used in developing countries to provide guidance in the design of overall development strategies.¹⁷⁻²¹ This is precisely where the approaches and methodologies developed in global modelling can be most helpful.

There is now a clear need to develop a new generation of exploratory simulation tools to focus on the overall strategic concerns of policy- and decision-makers in developing countries.²² Comprehensive (or 'global') nation-level models should capture and reflect the essential features of the options, choices and dilemmas faced by Third World policy- and decision-makers, while at the same time highlight the interactions between different development issues and the long-term consequences of alternative courses of action.

NATIONAL 'COMPREHENSIVE' MODELS IN THE THIRD WORLD: A RESEARCH AGENDA AND A CASE STUDY

As indicated above, the continued elaboration and refinement of global models as such faces diminishing returns to investment in effort and resources. However, the experience of two decades of global modelling exercises, and the many new concepts and techniques that emerged during this period, can be of great assistance in developing integrative and comprehensive modelling tools to explore alternative development strategies and policies in the Third World.

Considered from a technical standpoint, this could be a relatively simple undertaking—particularly when compared with the more complex task of constructing global models at the world level. But taking into account the difficulties faced by model-builders in developing countries,²³ and adding the condition that the models should be used directly by policy- and decision-makers, the difficulties multiply and the task becomes even more complex than that of the global modellers of the 1970s and early 1980s.

The main objective of this new generation of modelling approaches and tools should be to improve the quality and transparency of policy- and decision-making at the national level. This implies the use of modelling techniques that are easy to understand and can be readily explained to those involved in the design and implementation of development strategies. Furthermore, because of the wide range and changing nature of the concerns of policy- and decision-makers, models should be flexible, capable of being used in both the extrapolative and normative modes, and easy to modify and expand—particularly taking into account the limited availability of data. In addition, model-building activities should be complemented with the analysis of qualitative scenarios, with the identification of new and the impact of external constraints and opportunities, and with extensive dissemination activities.

These requirements could be taken as a research agenda for the next generation of 'global' model-building efforts at the national level and for the design of modelling tools and computer software. The nature of the task can be highlighted more clearly by reviewing some features and results of an attempt to proceed along these lines: the programme of studies and research on 'Long-term development options and strategies for Peru', carried out at the Grupo de Analisis para el Desarrollo (GRADE) in Lima.²⁴

The objectives of the GRADE programme of studies are to outline the viable paths for the future socio-economic evolution of Peru, to define alternative sets of long-term objectives and

visions for the future of the country, to assess the possible impact of international trends in the design of long-term development strategies, to identify the critical policy decisions to be made during the next two decades, and to derive the institutional implications of these studies for the organization of planning activities. The first project in the GRADE programme of studies involved the construction of several interacting computer simulation models to explore long-term policy options.²⁵ The difficulties encountered in this project, together with the author's assessment of model-building efforts in developing countries during the last two decades,²⁶ provide the basis for the discussion that follows.

The first problem that will be encountered in constructing comprehensive policy-exploration models in developing countries is *the lack of reliable data and statistical information* (notice that because of the highly aggregate nature, global models faced less of a problem in this regard). In the case of the work at GRADE, it was necessary to make extensive efforts to obtain, classify and evaluate quantitative information about a wide range of variables, and it took a team of four researchers one year to organize a data base with more than 1500 statistical series. Several additional months were required to reconstruct many of these series, checking their consistency, developing new indicators and selecting the variables to be used in the simulation models.

The knowledge acquired in this process facilitated the simplification of model-building tasks. For example, some statistical series are gathered or estimated with a relatively large margin for error (e.g. sectoral distribution of the economically active population), and there is no point in constructing models with equations that attempt to provide more precision than the data allows. In addition, many suggestions to improve the quality and availability of statistical information were derived from these data-gathering efforts.

A second problem is related to the *lack of experience in building policy-oriented models*. Most systems analysts and operational research specialists in developing countries are accustomed to working with models that optimize objective functions subject to well-defined constraints, or that simulate the operation of well-structured systems; they are not comfortable with the ambiguous and open-ended nature of most policy experimentation exercises. The transition from short- and medium-term operational modelling towards long-term strategic modelling is rather difficult to make, particularly for professionals with long experience in the first type of model.

For example, one of the specialists that the GRADE team came into contact with had built a 10,000 variable and 1,200 equation linear programming model to optimize agricultural production in Peru during the 1970s. He was taken aback by the fact that the GRADE team intended to build a relatively simple simulation model, with several dozen variables and a limited number of equations, to explore policy options in agricultural development. It was rather difficult for him to understand that no senior-level policy-maker is likely to make a strategy or policy decision on the basis of a large-scale short-term optimization model. In this regard, it is useful to recall a point made by House²⁷ in his review of the policy-modelling experience of the Federal Government in the United States of America:

The more models are designed to amplify the sometimes disorganized storage and retrieval capacity of the mind and the less to predict actions and reactions in a way no analyst would, the better off the models will be for policy use. Larger, complex models that are difficult to understand are possibly useful for research purposes but are normally of limited use in the policy arena (pp. 174–175).

A third problem that will be encountered in the construction of national comprehensive models in developing countries relates to the *lack of experience and unwillingness of policy-makers to work with mathematical models*. However, rather than trying to 'educate' policy- and decision-makers in the use of sophisticated modelling tools, it is more productive to develop modelling techniques and tools that could be within their reach. One of the senior GRADE researchers referred to this as building 'minister-proof models'. According to him, 'if a minister understands the model, then it is at the adequate level of complexity; if he does not, then build a simpler model'.

The extensive availability of microcomputers and of software programs such as Lotus 1-2-3—which have spawned a worldwide 'spreadsheet culture' among managers, government officials and other professionals—led GRADE to the use of spreadsheets for constructing its policy-exploration models in the early 1980s. Simplified spreadsheet models provided the interface with users, and an array of econometric and statistical techniques has been employed to derive most of

the coefficients and parameters incorporated in these models. However, the user did not need to know the complex set of equations that supported the several spreadsheets involved in each of the sectoral and consistency models (for example, the energy options model alone uses about a dozen different spreadsheets, each with its particular set of coefficients, parameters and policy variables). The researchers at GRADE were aware that the use of this type of software in policy-exploration models imposes a series of limitations, and future versions of the models will probably combine spreadsheets with other modelling tools.

Several conferences, seminars and meetings were organized to familiarize potential users with the models. Government officials, public and private sector managers and professionals were invited to a series of presentations of the models and shown the strategic implications of the results. This helped to overcome the reluctance of senior policy- and decision-makers to use computer simulation models for the exploration of long-term policy options.²⁸

A fourth problem in moving to the proposed next stage in global modelling arises because of the scarcity of financial, physical and human resources to support model-building activities. For example, in the case of the GRADE programme of studies and research on future development options and strategies, it was necessary to obtain external financial support to begin with the first project on long-term viable options (the Canadian International Development Agency provided the first grant), and local support from government agencies and private enterprises became available only after the first set of results was obtained.

Making a virtue out of necessity, in the early 1980s it was decided to construct the initial models using the spreadsheet program VisiCalc in a very small microcomputer (an Apple IIe with 64K of memory), thus reducing the temptation to add more equations unless they became really necessary. Subsequently, all the models were translated into Lotus 1-2-3 and now run in any IBM-compatible microcomputer with at least 512K of memory. This stands in contrast with other exercises of a similar nature, where expensive microcomputers or workstations were considered necessary and new software had to be developed from scratch. For example, in the mid-1980s a project sponsored by the International Institute for Applied Systems Analysis (IIASA) to explore resource utilization patterns in one province of the People's Republic of China required the use of a US \$50,000 workstation and the adaptation of rather complex special-purpose software developed at IIASA.

As mentioned before, one of the problems usually encountered in developing countries is the lack of personnel with experience in the construction of policy-oriented models. The few professionals with expertise in model-building usually have worked in large-scale operational models, and only in recent years—after microcomputers became widely available—has there been the

possibility of training systems analysts, programmers and software users to have more experience in model-building. In the case of the GRADE team, only the project leader had previous experience in policy-oriented models, and with the assistance of two outside experts, it became necessary to organize an accelerated on-the-job training programme for the young researchers.

A final problem refers to the institutional instability that affects the policy-making process in developing countries. It is seldom the case that a governmental agency is able to maintain continuity in model-building activities, to accumulate experience and expertise in the use of policy-oriented models, and to keep track of the various changes and improvements involved in their development. This lack of institutional memory in most government agencies makes it necessary to rely on the support of non-governmental organizations, universities, independent research groups (such as GRADE in Peru), consulting firms, information services organizations, etc. to provide continuity in model-building efforts.

CONCLUDING REMARKS

The lack of reliable statistical information, the lack of experience with policy-oriented models, the resistance of policy- and decision-makers to using simulation models, the general scarcity of financial resources, and the instability of policy-making agencies all add to a rather complex set of challenges in the development of practical and useful models to explore long-term development options and strategies for Third World countries.

The extremely rich and varied experience acquired during the 1970s and 1980s in global modelling should be brought to bear in meeting these challenges by proceeding to what may be considered as a new stage in the evolution of global-modelling approaches, methodologies and techniques. This implies focussing on the need to develop comprehensive ('global') national models to experiment with alternative development strategies and policies. The experience of several futures research programmes under way in developing countries—such as that being carried out at GRADE—indicates that this is a viable proposition and can be worth undertaking.

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