Scenario Models of the World Economy

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Sir Richard Stone (1913-1991) Premio Nobel de economía 1984, colaborador de J.M. Keynes durante la guerra, ha aportado a la economía los principios de la cuantificación rigurosa, desarrollando la contabilidad nacional y social, y ha sido pionero en el campo de la modelización macro y meso económica y de su utilización para la exploración y previsión de la evolución de la economía.

El Fondo de Investigación e Innovación Richard Stone (FIIRS) ha sido constituido para potenciar la actividad investigadora básica y aplicada y la difusión académica de sus resultados y facilitar así el pleno desarrollo de las carreras investigadoras en el Instituto L.R. Klein - Centro Stone.

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1.- Introduction

The purpose of this paper is threefold: First it discusses the case for building an IO-based model of the world economy, second, it discusses the type and the necessary characteristics of such a model and finally it highlights a road map for its construction. In the process it argues for the following set of propositions: a) the necessity of reviving the notion of world models b) the need to take on simultaneously the social-economic and environmental challenges and their interdependence c) the suitability of the IO framework as the basis of the next generation of world models d) the importance of bringing theory to bear on the development of the model and on policy analysis e) the importance of community for the development, support and diffusion of the model and its uses f) asserting the importance of the role of IIOA in building that community g) a focus on interdisciplinarity rather than on the export of economic logic alone to the social and environmental dimensions h) the importance of a scenario-based approach and i) the need to develop and integrate the financial side along with the real side of the economy.

2.- The Challenge of the global economy

The global concerns over the human impact on climate and the environment and over the unsustainability of social and economic development led to a series of world meetings bringing together representatives of world governments, civil society and international organizations aiming at the mobilization of global interest and its translation into effective policy through international agreements. The first Earth Summit, held in Rio de Janeiro, Brazil, in 1992 has popularized the notion of sustainable development and defined the framework for further agreements and summits including the UN Millennium goals in 2000, and the recent World Summit on Sustainable Development (WSSD 2002 in Johannesburg, South Africa) ten years after the creation of Agenda 21. Notwithstanding some important achievements, including the promotion of a global consciousness and the establishing of world conferences as a part of the world culture of governance, there seem to be a widely shared agreement regarding the failure of the overall performance with respect to the repeatedly stated goals. Moreover no new vision has emerged of what a radically different set of policy actions could achieve.

More than ever there is a need to articulate a clear approach to sustainable development in its social, environmental and economic dimensions based on the exploration of alternative courses of action capable of transforming significantly the current structure on a global level. Such an approach would need to be framed by the context globalization and elaborate the linkage between financial integration and development and rooted in the systematic analysis of empirical reality, theoretical knowledge and creative propositions.

2.1.- The challenge to global analysis

The pros and cons of globalization have been strongly contested and the debate induces contradictory responses expressed in a variety of forms, from academic discord to political debate and mass street protests at meetings of world leaders. In the process it has generated a substantial mobilization of interest from many actors in the world and as such, created a space for broad analytical devices to play the crucial role in clarifying the alternatives and consequences of various development paths on a global scale.

The word “globalization” is often used at present to reflect a growing trend for supra-nationalization: global phenomena are taking place at world level beyond the institutional frameworks of the nation-states. This is the case in the globalization of finance, the globalization of science, the globalization of the environment and ultimately of governance. World modeling has strongly contributed to these new global perceptions. In the 1970’s, Forrester proposal for dynamic modeling concentrated already on the properties of world systems rather than in their institutional character. While very criticized in academic circles, the model of the Club of Rome started a process of increasing consciousness of the issues of globalization, and was to be followed by other large-scale modeling efforts, including the Leontief-Carter-Petri UN model initiated in 1975 and later continued updated and expanded by Duchin et al at the Institute for Economic Analysis. This Leontief world model used extensively input-output analysis (Leontief et. al. 1977; its main characteristics have been reviewed recently in Fontela, 2000), and explored a set of alternative scenarios mainly dictated by UN objectives for economic development.

The Seventh International Input-Output Conference (Innsbruck, 1979) devoted several sessions to World models with contributions by the UN Secretariat, UNIDO, the Economic Commission for Asia and the Pacific of the UN, IIASA and the World Bank (see UNIDO, 1984).

After the boom of world modeling in the seventies, however, there has been a nearly complete lack of interest during the following twenty years. While the oil shock and the currency floating probably increased the feeling of world interdependence, it also encouraged the idea of more local or national solutions. Besides that, there was an increasing dissatisfaction with models intended to explore long-term futures, and with the high level of unwarranted subjectivity of the model builders. At the same time, specially after the end of the ideological confrontation between market and centrally planned economies, there started to be a shared feeling among economists that a better functioning of markets should possibly avoid world crisis. After all, in the 80's and 90's floating prices and new technologies had avoided new oils crisis, and the problem of possible exhaustion of natural resources should probably also be solved by other new price and technological change mechanisms.

However with the severity of the financial crises in the late 90's and at the beginning of the XXIst Century it is becoming increasingly obvious that the process of globalization is not perceived in a similar way by all the agents of the world system; for some nations, firms and individuals competitiveness in global economic environments is a source of income and wealth; for other in the contrary it is a cause of poverty and despair, sometimes leading to critical events (such as the Seattle protests). Criticism of globalization is already hindering international developments, such as those promoted by the IMF and the WTO. The time is right for exploring global alternatives for long-term futures development. The international organizations, the anti-globalization movements and the sustainable growth promoters, the financial communities and the multinational corporations that are now planning global strategies, all need technical instruments to bring the debates to manageable terms.

Exploring the long-term future is partly an artistic activity, but it requires the methodological robustness of science. In fact, it calls upon a combination of quantitative modeling and qualitative scenario building. Economists tend to concentrate in modeling, letting to future's researchers the responsibility for the softer characteristics of complex systems, and in particular their multidisciplinary aspects. It seems clear that a methodologically sound coupling of economic modeling and futures-inspired scenario analysis is needed to provide insight as to what the future may have in store and to our margin for having an impact in areas that seem crucial or at turning points, and by doing so deepen understanding of possible implications of different paths that could be followed.

2.2.- The Challenge to IO

The strength of the IO structural framework has relied essentially on its capacity to portray the "real" side of the economy and analyze structural change nationally or regionally, initially in production technologies, more recently in household lifestyles and income distribution patterns. Also, the ability to insightfully and meaningfully assess the impact of human activity, including the structural changes mentioned above, on the environment in terms of utilization of resources and the generation of waste and pollutants has been shown repeatedly to be a characteristic property of IO based models. It is clear that the numerous issues that fall within that broad description, from access to clean water per-capita to oil reserves depletion and greenhouse gases released will continue to be a fundamental part of the global concerns. Refinements of the analytical framework could be achieved for the specific issues and the general soundness of the approach and its abilities to deal with both the physical and monetary aspect of transactions and uses could be relied upon to generate relevant insights into that aspect of the global order and to issues that are at the center of society's concerns. These achievements have been due in part to the widespread adoption of the IO framework in the fields of Industrial Ecology and Ecological Economics that were able to exploit some of its unique characteristics that make it amenable to trans/interdisciplinary research.

The challenge is to see to what extent we can devise a global model that could deliver the same type of insights as in the case of the environmental dimension, into the other domain of great concern in this era. In particular the broad areas of finance and monetary mechanisms and information-based structural change in production and organization have been seen as hallmarks of the contemporary economic systems while the issues of massive poverty and low standards of living in vast segments of the globe as well as new forms of these perennial problems, such as the digital divide or the de-linking of some countries from the international system, are perceived to be the corresponding pathologies. Related issues include that of the reform of international financial governance, including the regulation of WTO decision making process, IMF conditionality and stabilization programs and the like, contagion effects of financial and political instability, locational decision of MNC and determinants of FDI and their consequences, labor/children rights and abuse in the work place, gender equity, property rights on knowledge and patents on genetic and medical information, cultural invasions and clashes of cultures. So the issues related to the financial, informational, cultural and institutional domains are at the center of the discussions around the larger issue of the new global order that is emerging in the 21st century. What can we say about those issues, their consequence? How can they be incorporated in our thinking? While they are hard to model comprehensively, we need to find and explain the links between some of those issues and the phenomena that we are able to explain, analyze or model, either through an understanding of related underlying factors, providing input to their analysis elsewhere, or a delimiting of the broad outlines of their consequences. It is clear that the challenge is both theoretical and empirical. The theoretical apparatus of the IO model has to be vastly expanded in a variety of directions in such a way as to provide an appealing challenge to economic theorists while keeping a close link to the empirical content and requirements. In the paper we suggest a modular structure for the model that will allow such a diverse set of issues to be tackled in a loosely connected variety of ways to be coupled with scenario analysis in the context of a global model.

We could try to conceive a measure of “distance” of the various issues with respect to our desire/ability to deal with them. To use simple and extreme examples, we can say that, for instance, the issue of the quantities of oil required and the amount of carbon dioxide released following an assumed level of car utilization in China in the next decade is in a rather near neighborhood, whereas the assessment of the risk of a currency crisis contagion from Thailand to Chile are very far on that same scale. Somewhere in the middle is the analysis of global production chains of multinationals, the cost based assessment and market potential of foreign direct investment in manufacturing and so forth. The ranking of issues does not have to be on a simple linear scale.

3.- Embedding Global Models in a Community

This paper calls for a major effort by the IO community to be involved in a research program to construct IO-based models of the global economy that will act as a major focus of a strategy to organize and re-assert its relevance in this era in the academic and policy realms. The challenge to provide a platform that allows a wide variety of concerned agents and institutions to interact on issues related to global change in the world economy is out there and the void of comprehensive analysis on a global scale has not been adequately filled yet.

It is our belief that the IO and structural economics field has unique features and an important set of collective experience that will allow it to build a platform to bridge the interests and channel the contributions of the theorists and the practitioners in the debate surrounding the formation of a global economy. This involves however a major effort in three directions: 1) towards new theoretical modeling, 2) towards policy relevance and 3) towards an organizational set-up.

In this section we deal with the organization of the process of building the model which should involve, we argue, the simultaneous organization of a community – of scientists and involved institutions and agents- around the issue of global structural change and its modeling. We view both processes of community and model building as interrelated and in some sense inseparable. The feedback between the two is explored below. We also propose an organizational structure and a series of concrete steps to launch that effort in the IIOA, further completed in section 5, by a guideline for the design of these activities.

3.1.- The role of communities

Much can be learned from the success of the community built around the issue of climate change around the IPCC and centered on the use of the comprehensive climate models, the so-called global circulation models (GCM). A large part of the wide recognition of the importance of climate change both in attracting the involvement and interest of a large number of scientists and of society at large including civil society and the policy making realms is due to the successful community building that has been achieved through the networking of scientists in various disciplines with a focus on the construction of comprehensive GCMs – what has been called an “epistemic community”- and the expansion of their network to include a representation of a broad spectrum of society internationally. (Edwards 1996).

An epistemic community is a knowledge-based network of professionals with competence in particular research areas and sharing among other things a set of beliefs regarding the value of the issues, the causal relationships explaining the phenomena and the methods of investigations and validation. The success of such communities in terms of the attention they generate and influence they have on policy depends in large part on the complexity of the issues involved. The fundamental uncertainty of many global problems forces institutions, and policy makers, to enlist the help of knowledge networks and epistemic communities, as the standard responses based on preconceived views of the world fail to provide adequate guidance to the solution of the problems faced (Haas 1992). It should be added that that same complexity imposes on the modeling effort constraints such that isolated researchers are unable to cope with the demands of the analysis when it is required. This is also the case with global sustainable development- the “world problematique” – that while making international cooperation increasingly necessary the complexity of processes at work and the uncertainty of their outcomes renders such cooperation more difficult. The prognoses of various policies are much contested. There are of course a number of knowledge-networks and communities dealing with various aspects of this problem from a variety of angles. However major advances in global scale modeling could be achieved by a framework that provides for linkages among sets of research teams. A coordinated but dispersed community that links rather small team of researchers to deal with the complexity of the tasks, while fostering a mix of cooperation and competition in the concepts that would be adapted and keeping up to date with respect to techniques, theoretical advances and relevance with regard to policy and issues would be desirable and effective.

The creation of such a community around the issues of the world economy including sustainable global development is entirely feasible and the IO association is an excellent place to start it. The way we envision the building of the model is through a process somewhat like the open-source software development that evolves through the collaboration of a distributed set of contributors that respond to needs expressed in various instances within some accepted parameters for interaction. As the model progress so does the community around it, which would reach further out into including not only economists, but social scientists, policymakers and involved members and institutions of civil society as well. This process allows a continuous exposure to new theoretical developments, new ideas concerning the important scenarios to explore, the relative importance of various issues as expressed by involved institutions and people in civil society and governments as well as generating a wider net of interest in various levels of society.

3.2.- The Role of Models in Creating Communities

Creating a scenario-based IO model of global change as we conceive it and a geographically, disciplinary and functionally distributed community of practitioners and contributors around it is a major enterprise with significant benefits to the IO and structural economics community at large. An IO-based modular system would provide a major boost for the integration of insights from various research areas 1) within the IO disciplines, focusing on theoretical development and integration of the database. With an overarching focus it would allow various parts of the IO-based research communities such those working with SAMs, CGE and Dynamic IO to inform each other and help move beyond a sterile confrontation, 2) with related disciplines such as ecological economics, industrial ecology and energy economics which are well established fields in which IO has been a strong influence 3) with economic theorists especially international finance and trade and 4) with other social scientists including sociologists, anthropologists and futurists involved in the construction of scenarios and the interpretation of the results.

Global models can be viewed as platform for integrating results and insights from many different fields of research and disciplines. Each must ultimately formulate its data to “talk” to each other as to be able to feed the model; they force a common language and structures communication. They provide a theory to guiding data collection, a frame of reference for data collection integrating data from various disciplines and various parts of the world transforming local data into global sets. (Edwards 1996)

Models like a scenario-based global IO, an expandable set of loosely coupled modules - would serve also as heuristic guide to the complex issues. While not a predictive tool, they can guide and inform policy by framing the issues, clarifying the structure of the problems and provide a wide set of creative ideas for bold actions. Through the community effect it helps to establish a common perception of the issues and of the risks involved with alternative courses of actions. So a comprehensive model of the global economy based on IO and scenario analysis would have a strong impact on the IO discipline by placing it at the center of a major inter-disciplinary efforts – which it has proved to be able to do in various separate instances – situating it strongly within the economics profession while also providing it with an epistemological bridge to other disciplines and a connection to the policy realm and the broader segments of society through the sustaining of a community around the model. Such communities are important in generating acceptance and respect for the work undertaken, develops its own criteria for excellence and thus empowers its members through internal and external incentives.

The first step in building the model is the constitution of a core group, the nucleus of the scientific network that will initiate the development of the model and guide the process of successive enlargement of that group and ultimately produce the first prototype of the model. This group would be the equivalent of the “maintainer” in the open-source development community, which has also been portrayed as an epistemic community (Kaspar Edwards, 2001). The maintainer is the central person or group in the community often the originator of the idea and the initial version of the software that the project is developing. The maintainer releases the code, the "contributors" identify problems and/or needed features, develop solutions and send them to maintainer, who has the final say as to what should get incorporated into the software.

4.- Scenario Models of the World Economy

To build a model of a phenomenon, such as the world economy, requires identifying its critical features and understanding the relationships among them. There are decisions to be made about the appropriate level of detail for describing the features, notably the choice of the units of analysis. One has to understand how the features and the relationships do, or may, change over time. Economic models include mental models, which are theories about these relationships, and mathematical models, which represent the relationships in a concise notation. In a mathematical model the features become the variables, measured in specified units, and related in equations through parameters.

A theoretical model is not necessarily accompanied by a mathematical model. Most mathematical models, however, are based on a theoretical model. The relationship to the theoretical model ranges from completely faithful to very loose. There are several reasons that the two may not be tightly coupled. The theory may not be formulated in terms of observable variables and parameters, the data may be conceptually obtainable but not available, or the model may for any number of reasons be an intentional simplification. Our feeling is that the theory and mathematical model (simply “model” from now on) should be developed in parallel so that the fit between them can be close.

In applied areas where relationships are governed by laws of nature, equations may contain only variables and constants. This is the case in some areas of physics. In other applications, models require parameters that need to be quantified under varying circumstances. The quality of a model can often be judged by the choice of parameters and the methods for quantifying them. A model of the world economy clearly requires a substantial empirical content, and this is why input-output economics is well placed to take on this challenge.

A model of the world economy needs to represent production, consumption, and the exchange of goods and services in sectorally, institutionally, temporally and geographically disaggregated detail; the associated costs and prices; inputs from the natural world and discharges to it; savings, investment, and capital flows. Innovations in technology and in lifestyle are the major motors for economic development. The theory and model need to be capable of representing these features and their relationships both conceptually and empirically.

4.1.- Purposes of a New Model of the World Economy

One motivation for building a model is to assist in the development of theories and to test theories. Because mathematical notation is compact, a model helps clarify assumptions and discipline deductions. It is clear that input-output theory needs to be extended to provide the basis for a new generation model of the world economy. Some of the urgent needs are for a theory of trade, of financial flows, and of lifestyle innovation, all at the conceptual level of the global economy. Samuelson's Factor Price Equalization theorem and Leontief 's trade paradox are good examples of theory development and theory testing based in the first instance on logical deduction alone and in the second requiring also the quantification of variables and parameters.

The new model needs to faithfully represent the underlying theory and to be able to test it. Yet it needs also to serve practical purposes, namely to analyze scenarios relevant to contemporary problems for which theory may still be lagging. There is substantial and unavoidable tension between a theoretically useful model and a practical, or production, model. The close relation to theory, indispensable for a research model, is sacrificed to differing degrees for a production model. The challenge is for the community to support both kinds of models but to know the difference between them and encourage feedback in both directions. New work with research models is needed to periodically renew the production models. Problems encountered with production models can indicate where new theoretical efforts need to be focused. Nonetheless, there is substantial overlap between the two kinds of models, and we will not always maintain a sharp distinction in the remarks that follow.

There is not a truly integrated economic theory to guide the construction of a model of the world economy at the intermediate or meso-level detail. Nonetheless, it is clear that research models can and need to be developed for improving different bodies of theory. Rather than reflecting only formal relationships, a model of the world economy requires the quantification of many variables and parameters. Developing this empirical content is a substantial challenge dependent on data from national statistical offices as well as specialized sources. The effective incorporation of a large body of data into the modeling framework requires not only well-structured databases but also scenarios to structure the assumptions about relationships. The amount of effort required to build the database is generally recognized. However, the amount of effort required for developing scenarios is generally underestimated, as is the effort needed for systematic interpretation of results whose level of detail matches that of the scenarios and database.

Research models are used for exploration and can be changed quickly by the individual researcher or team. Production models are necessarily slower to change because they are used by a larger community that needs documentation, stability, and explicit mechanisms for making changes to the common model.

Global circulation models of the atmosphere and the oceans are an example of where theorists have become increasingly engaged with production models for a variety of reasons, and the production models are periodically improved in light of new research developments. These models illustrate the value of thematic focus for improving production models. A researcher can model a specific phenomenon, say, sea ice or cloud formation, independently and then that module can be incorporated into the production model. In the case of a model of the world economy, modules might be about the use of water as a factor of production, or adding the representation of financial flows, or increasing the number of categories of households whose labor and consumption are represented. One of the motivations for a new model of the world economy is for it to satisfy better the concerns of trade theorists, who cannot test general propositions about comparative advantage using existing models of the global system.

4.2.- Meso-Level Models

A macroeconomic model deals with the major aggregates comprising value added on the one hand or final deliveries on the other. A microeconomic model deals with equilibrium outcomes reached by rational agents in competitive markets. Input-output models are sometimes considered a subset of the one and sometimes of the other. At the limit, input-output models could be extremely aggregated, and therefore closer to a macro-level of detail, or disaggregated to the point of distinguishing establishments or even individuals. However, their distinctive strength is their ability to represent economic activities at a meso-level of detail, with industrial sectors and household types as the units of analysis, intermediate between the major aggregates and the individual establishments and consumers. For this reason the input-output based family of models is distinguished by the meso-level of analysis it can support.

The basic input-output model is the open static physical model, (I A) x = y. About 70 years after its creation, it is still the workhorse of applied input-output analysis. The open static price model takes the form (I A)’ p = v. The 2 basic models are linked by the income equation, p’y = v’x (Duchin, 198x). The main reason that the price model is less frequently used is that the physical model is usually expressed in money units of measure. With the increasing frequency of use of input-output models for environmental analysis, including material flow analysis and life-cycle analysis, the price model will also be used more frequently.

The basic model, physical and price combined, is called open because it requires the exogenous specification of several variables before a computation can be made. The model is solved for x and p, given A, y, and v. But y is the sum of C, I, G, E, M, each of which is thus exogenous, and v is the product of factor requirements and factor prices, which are likewise exogenously fixed. Many of the advances on the basic input-output model consist of "closing" the model by making one or more of these variables endogenous. Achieving this closure requires equations relating the source of funds to each of these expenditure categories. Thus a dynamic model is closed for investment and savings; a model closed for consumption and employment and for government revenues and expenditures can be called a SAM-based model; and a model closed for imports and exports of all regions of the world economy can be called a world model. A new generation model of the world economy should be a meso-level model with all of these closures.

4.3.- Scenario-Based Modeling

Effective use of a model of the world economy is part of a process with 5 components: theory, scenarios, data, model, and interpretation. Modeling is at its most successful when there is substantial and ongoing feedback among them.

Types of scenarios and methods for building them, the focus of another session (IV. 7.2) at this meeting, are discussed in the next section. There it is pointed out that designing scenarios is an interdisciplinary challenge that can usefully involve the collaboration of economists with futurists. The subsequent challenge is to translate the scenario into values of variables and parameters that enter into the model computation. A major shortcoming of many modeling exercises is that the scenarios that are stated are not the ones actually analyzed because the model is not sufficiently disaggregated geographically, sectorally temporally or institutionally to represent the assumptions.

The key to this quantification is the input-output case study, first used by Professor Leontief and his colleagues (Leontief et al, 1954) and refined in the subsequent studies carried out at the Institute for Economic Analysis at New York University (Duchin and Lange, 1994). The choice of topic is dictated by the scenarios, while the objects to be quantified depend upon the equations. The objective is to flesh out the story line of the scenario while also meeting the needs of the modeling exercise.

The lack of reaction to prices and technological change has constituted a main handicap for exploring the future in the Leontief's model (as well as in Forrester's model, and in general in all modeling efforts of the seventies). This is the main area in which a static context is expected to be completed by dynamic processes, including behavioral microeconomic reactions. This line of thought is continuously strengthened in existing multisectoral models (e.g. INFORUM or the Cambridge E-3 model), as well as in General Equilibrium Models. The endogenous consideration of technological change in production functions opens the way to new forms of modeling styles that could also inspire global modeling.

Interaction among academic colleagues of different disciplines and specialties requires an iterative process involving both theory and data. Theory delimits the scope of issues covered, but the issues to be covered specify theoretical needs. Treating the scenarios as an integral part of the model can help reconcile different viewpoints on the scope of factors to be included early in the process. Along with the modular aspect of the model, the strong integration of scenarios with the rest of the analytical work would allow the integration of demographic, political and social processes into the model when it is needed. Work has to be done regarding structuring scenarios and specifying the architecture of the model (Nauphal 1999.)

There are thee ways issues can be dealt with *directly* in the model. First, they may be represented in the fundamental relationships of the model, in the core of the model. This may not be possible if the representation depends on relationships where the linkages are not well understood. In this case, the issues should be dealt with in satellite models that meet the experts' criteria for quality and then are integrated only loosely with the core model. Alternatively the issues may be represented as alternative values for exogenous variables in the scenarios. Finally they can be dealt with *indirectly* in a discursive analysis that provides a context for interpreting the formal results. A combination of these methods will allow the insights of different kinds of scholars including other social scientists notably anthropologists, sociologists, and psychologists into the picture while maintaining the intellectual integrity of the ensemble.

Even when they are useful for testing theory, large, data-dependent models cannot be expected to achieve precise results. Their power lies instead in order-of-magnitude estimates that can provide a definitive answer to certain types of questions. However, only a small portion of empirical modeling exercises reaches definitive conclusions. Perhaps the most significant example is the computation of Leontief’s Paradox. (While the result was definitive, the interpretation remains unresolved to this day.)

In the authors’ personal experiences with economic models and scenarios of now several decades, there are only a small number of instances where we were able to pose a well-defined question and answer it in a definitive way. In one case, the Deputy Minister of Planning of Indonesia sketched for the research team the official "plan" for agriculture: upgrading of the diet to more produce and animal products for an increasing population, taking land (the most fertile) in Java out of cultivation because of urbanization pressures, and continued self-sufficiency in fertilizers and in food. This was to be achieved through better choice of crops and improvements in yields. Although we obtained optimistic projections about yields from a team of Indonesian agricultural experts, we found that the demand could not be satisfied. Only then was the Minister willing to ask how much food they would have to import, to which we were able to provide an order-of-magnitude response (Duchin et al, 1993). A second case was our use of a model of the world economy to examine the feasibility of the recommendations for avoiding environmental disaster of the Brundtland Report. We concluded that the strategies of the Brundtland Report were not feasible, in that it was much too optimistic that those means could obtain those ends (Duchin and Lange, 1994).

Many scenarios analyzed with models are highly simplified. In other cases the scenarios are interesting but unfortunately get reduced to a small number of figures before the formal analysis is conducted. Most futurist scenarios display imagination but need a firmer conceptual structure and more disciplined methods.

A new approach to scenarios is needed to formulate ones that can be analyzed with a new generation world model. While the model is specified in terms of scope, modularity, theoretical basis for relationships, etc., ultimately it is represented in terms of variables and parameters describing production, exchange, and consumption. Alternative scenarios need to be formulated in terms of these same building blocks - requiring specific commonalities of mindset on the parts of the scenario builders, modelers and data specialists. The partners need not only specialized knowledge but also the willingness to accept the mutual constraints of collaborating with economist modelers who believe they understand production, exchange, and consumption, and data experts who know what is realistic for a data collection campaign.

4.4.- Futures Research and Scenarios

Futures research emerged as a rigorous discipline, in close liaison with operations research, after the Second World War as a provider of objectives for optimal long-term decision-making. The Rand Corporation plays an important pioneering role while focusing on technological long term forecasting, in the late 50's (Dalkey, Helmer, 1963) using the Delphi method (an interactive process of consultations for expert consensus) Herman Kahn (1960) brought scenarios about crucial strategic defense issues to a wider public. In Europe, Bertrand de Jouvenel (1964) sets the foundations of "Prospective" the "art" of exploring alternative futures. Soon afterwards, T.H. Gordon (1968) introduced cross-impact analysis, a method that promoted the convergence of American and French approaches into the common idea of "scenario writing". In the early seventies, Futures Research had consolidated around the following topics and instruments:

Topics	Instruments
Experts views about the future	Delphi Brainstorming
Understanding relations between future events, trends and actions	Cross-impact analysis System Dynamics
Portraying structures of complex ill-defined systems	Morphological analysis Interpretive structural modeling
Describing alternative futures	Scenario writing
Note: For a description of these tools, see Godet (1993).	

Since then, Gordon (1994) revisited the original link with operations research, introducing in futures research tools of decision analysis under uncertainty (utility matrices, pay off matrices).

Futures research has progressively evolved from the initial ideas about forecasting or simply “prospective”, into the notion of providing inputs to policy making (Godet, 1993). Many of the tools are integrated in strategic planning, especially those dealing with the search for expert consensus (e.g. in the area of technological foresight) and with the exploration of alternative futures (e.g. the use of scenarios by corporations).

Several journals (Futures, Foresight, Futuribles, Technological and Social Change, etc.) report the continuous progress of futures research that has also gained academic status in several universities.

The specific methods of futures research rely upon:

- the analysis of complexity, including identification of structures, morphological analysis, and systems functions (Warlfield, 1976), linking with systems sciences;
- the study of behavior of agents (economic, social, political, etc) and of their decision-making processes, thus linking specifically with developments in management sciences;
- the study of processes for expert consultation and consensus development, of great importance for the anticipatory perception of the functioning of systems for which scientific knowledge is still uncompleted; futures research has developed well known convergence processes as Delphi or Cross-Input Analysis;
- and scenario building, a flexible set of approaches for the consideration of evolution (from the present to the future) simulating behaviors of the agents of the system, under new constraints and situations (that can be derived form the analysis of complexity or from expert consultations). Scenario building is obviously the more creative (or “artistic”) component of Futures research.

As in the case of economic modeling, applied futures research has been mostly concentrated on exploring futures of economic agents, eventually of nations, rarely of the global system.

The consensus generating methods have gained full acceptance in technological foresight for the orientation of R&D programs, calling upon the yet unstructured knowledge of scientists and technologists.

Scenario techniques are very frequently used in strategic planning of large corporations, and this private request has provided the main stimulus for the new methodological development.

In Leontief's world model, there was a pioneering effort to include scenarios as a guide to model's projections. However, for model builders scenarios are essentially combinatory processes for the exogenous variables of the models. In some sense, all models are of the input-output type, and do process exogenous hypothetical factors into endogenous consequences. But all models, even global models (such as those developed by Leontief or envisaged here) will always represent **only** a fraction of the global systems, and thus their exogenous variables will only describe a very limited aspect of future alternatives.

An exogenous variable of the Leontief model, such as the growth of total income in a given region is obviously only a synthesis of an extremely complex set of assumptions about future political, institutional, social and obviously economic factors taking place in the region. It is for making explicit this complex set of assumptions, that futures research methodologies are required. The development of futures research has taken place at the frontier of many well-established disciplines, from mathematics to political science and philosophy. Thus, mathematics has provided the bayesian support to cross-impact analysis (see E. Fontela contribution in session IV. 7.2) and the construction of normative scenarios rely upon ethical propositions. The contacts with economics and econometric modeling, have been sporadic and not very fruitful, despite the fact that economics is a praxiologic science necessarily involved in the exploration of the future. One could even argue that economics should have provided the core of futures research, but this is far from being the case.

Let us see the possible relation between futures research and economic modeling in the context of world modeling. The reduced form of any model relates directly all exogenous to endogenous variables. It can be portrayed by two matrices of coefficients, matrix A relating the endogenous variables among themselves, and matrix B relating the exogenous to the endogenous variables. As the input output model is already written in a reduced form in this case, A is the coefficient table and B the final demand matrix.

We can say that matrix A models the internal workings of the system considered, while B relates the Outside systems to the modelled system.

	Model System	Outside
Model System	A	B

Now this is obviously the way economic models usually operate, and B provides a quantification of a scenario, when the economic model is used for exploration purposes. But it is quite evident that this view is incomplete. The final result of the endogenous variables of the system, after running of the model, does influence the Outside, and of course, there are interrelations within this outside world (that we know little about).

Thus a complete model of the global system should indeed refer to four interrelated matrices.

	Model System	Outside
Model System	A	B
Outside	C	D

Note that in the simplified context of a closed Leontief input-output system, or of a SAM, what we actually do is extend the frontiers of A towards covering more aspects of B, C and D, but remaining always within the strictly economic (and social) domain.

If we choose an economic system for A, then C will show the impact of the economic results on social relations, the environment, the political system etc, and D will portray the structural interrelations largely unknown, that exist between the different pieces of the outside puzzle.

Some parts of C can be quantified (see Duchin, Lange, 1994, on environment), but D is, in the present stage of our knowledge, ill defined and certainly non-quantifiable. However, relevant analysts may have unstructured theories or mental models related to D, and this is the best area for futures research methods such as Delphi (looking for consensus on perceptions of experts) or cross-impact (X-I) and Interpretive Structural Modeling (ISM).

To illustrate this point, let us suppose that we start considering a scenario of high economic growth in a context of a global market economy and continuous development of information technologies. These considerations help to fix the elements of matrix B. Now, in this same context, the relations of the model (matrix A) may lead to a sizeable digital divide between regions of the world, and this result is going to be reflected in matrix C.

Of course, a growing digital divide could increase the probability of a disruption of the market globalization process, as some regions may opt to withdraw from the process, and in this case matrix D alerts that the scenario should be somewhat modified.

If a Futures research method like Cross-Impact Analysis could be used to explore matrix D, the end result could provide expert opinion about the change in a priori probabilities of the scenarios considered. The scenario of high economic growth may not have the probability that we initially thought.

If we want to bring together Futures research and I/O modeling, then it seems that the scheme should incorporate both a formal model and a method to develop scenarios going well beyond the set of exogenous variables of this model (Fontela E. Gabus A. 1974; Fontela E. Sallin-Kornberg E., 1981; Alvarez Miranda F., Fontela E., 1980), that, is, we need an exploratory modeling system incorporating, as far as possible, all components of matrices A, B, C and D.

Traditional econometric modeling tend to concentrate the content of scenarios on the values of variables that appear in the columns of Matrix B; they normally assume that the structural coefficients of both A and B are the result of the econometric estimation procedure and are to be kept constant when simulating scenarios.

With input-output models the concept of scenario is extended to many technical components of the Matrices A and B, and this allows for a better fitting of expert ideas into the model (Duchin, Lange 1994). The more it is possible to transpose expert ideas into components of the model, the better the link between scenarios and models. For this to be true it is essential that the coefficient and relations of the model are easily interpreted in terms of simple relations: it is practically impossible to “inform” a coefficient estimated econometrically of outside ill-defined knowledge, but it is certainly possible to incorporate technical expertise into the coefficient of an input-output model.

5.- Outlining a world model

There is no shortage of economic models. Even models of the world economy have grown dramatically in number since the early days. But there is little point in going through the motions unless the model can provide definitive answers to relevant questions and has credibility in a community able to support the continuation of research and analysis.

Even though the weaknesses of using descriptive data only are widely recognized, the information content of the data may often be highly credible. Purely formal models that are not dependent on data may also have high credibility for their claim to illustrate a general process or outcome without specific empirical claims. But putting the 2 together, descriptive (as distinguished from illustrative) data plus mathematical model, greatly magnifies the implicit claim of understanding a process well enough to make quantitative statements about situations that are specific in time and place. In situations that are relatively well defined, such as certain medical or engineering simulations, such models have been able to demonstrate their contribution to understanding, but not so data-based mathematical models of the economy. They are seen as black boxes by both theorists, who are not tempted to test their theories using such models, and decision makers, who are rightly concerned about all the assumptions, especially the hidden ones.

The need for credibility is two sided. First, within the academic ranks of economists, social scientists and modelers, the objective is to attract collaborators to advance the theoretical basis of the model and widen its acceptance and refinements. Second, the modeling exercise must be able to tackle the issues that policy makers, activists, researchers, businesses and society at large care about. Modeling results need to provide valued input for decision making processes or promote deeper understanding for the major actors in the global economy: governments, corporations, supra-national institutions, NGO’s, households. These two concerns are distinct, hard to satisfy, and sometimes at cross-purposes, yet they must be met and in a balanced way so that the model creates a platform for interaction between these two disjointed groups.

5.1.- Model Requirement

Thirty years ago the challenge of building a world model raised many methodological and statistical difficulties; some of them (certainly not all of them!) can be dealt with much better in the present context with improved national accounting frameworks, more easily available data banks, and greater computing power. Furthermore, the notion of sustainable development has gained acceptance on as a basic value for testing alternative futures (0zbekham was launching the reference value of ecological balance in the early seventies; today, sustainability includes social and economic well-being besides ecological balance). We discuss below some of the overall requirements of a model of the world economy capable of providing a basis for such evaluations.

A model cannot represent everything but reflects a radical simplification of reality. In the authors’ opinions, Leontief’s World Model is the strongest starting point, but a new generation World Model needs to exhibit enlarged conceptual scope and theoretical completeness. The world model should be structural and mostly static, in order to connect easily with the variety that characterizes future scenarios. Once again, the Leontief model’s methodological choices were sound in this respect, as it is absolutely necessary to avoid as much as possible the black-box effects of excessive complexity. Dynamic processes, when introduced, should be backed by solid theoretical and empirical arguments. The basic features are meso-level conceptualization; data philosophy that specifies the data needs rather than working around the data currently available; assuring simplicity by favoring the first over the second of the following pairs where practical: static/dynamic, deterministic/probabilistic, satisficing/optimizing.

The core of the world model is comprised of a representation of the key features of the global economy: financial flows, flows of goods and services, the exchange of currencies, the generation and distribution of income, technology transfer (production), and lifestyle emulation (consumption). We should lay out what we need from theorists, from economists more generally, from statistical offices, from mathematicians, from futurists. For example, a literature on technology transfer could systematize what is known about the range of techniques in use in individual sectors. There only now begins to be a body of work that could do the same for lifestyle emulation - and we should jump into the breach to try to influence this work.

While models aiming at global analysis should have global components, it is clear that the notion of supra-nationalization has at first regional aspects. Leontief’s model was already on the right track in this respect. More attention however should be accorded to the relevant financial issues and their theoretical formulation than has been traditionally the case in IO economics. The more formally global components should be related to the financial world system for which globalization has been practically attained. The global link between savings and investments should act as a driving force for the rest of the supra-nationalization processes.

5.2.- Preliminary ideas about a world SAM

In some sense the notion of a world model - treating the world as being essentially a single unit though made up of clearly distinct and interacting sub-units - reflects a certain humanitarian statement. It forces an equality of principle on the various regions and people. It is a step towards a view of the world that transcends the particular national and ethnic identification; it forces a fair representation of the distribution of natural, human and produced resources as well as their movement across regions.

The power of IO and SAM accounting in providing a detailed yet graspable idea of the relative strength and dominance of various parts in the national economy/society would provide a sound assessment of those same relationships on a global scale. It is hard to imagine continuing to debate the global economy without having access to such a basic image of its shape.

The development of *national* accounts was a major success and so was the contribution of IO to it. As the statistical system was focused towards the analysis of strictly economic phenomena taking place on a national basis, reasonable information for building multi-dimensional world models including, in particular, social and environmental variables, was often lacking. The widespread adoption of the UN SNA-93 has considerably changed the situation with the general adoption of:

- Social Accounting Matrices (SAM)
- and the System of Environmental Accounts (SEA)

The components of SAM and SEA can be included in the definition of the structures at the meso-economic level.

A world model should portray the circular flows linking Production, Income, Consumption and Accumulation. Therefore, in essence, it could be a model based on a SAM (matrix A).

Table 1. An Aggregate SAM

	Production	Income	Accumulation
Production	1	C	I
Income	Y	2	
Accumulation		S	3

C = consumption; I = investment; Y = income; S = savings.

In **Table 1**, in the diagonal, 1 describes the relations between the components of productions (the **I/O subsystem**), 2 describes the processes of **Income redistribution**, and 3 the processes of **financial operations** or financial flows (capital stocks are not included in this description).

Basically matrix A portrays the macroeconomic relations of the world when the sub-matrices 1, 2 and 3 are equal to 0, and with dimensions 1 x 1, and the mesoeconomic relations when these sub-matrices have positive elements and many entries.

Of course, the classifications adopted by the meso-economic modelers to describe the agents and the functions at the levels of Production, Income and Accumulation, depend on the purposes of the model: thus, National Accounting reflects agreements between statistical offices that take into consideration the nature of the currently available statistical information, while SAMs with more detailed income processes (e.g. at the level of household characteristics) are of great interest for the economists analysis of development paths.

A detailed SAM would be needed to begin the discussion of the issues surrounding global sustainable development and the conceptual framework itself would have to be expanded and clarified. Besides the sectoral detail in each category of **Table 1**, special attention has to be provided to the representation of the Income Accounts. In effect these accounts represent institutions that need to be very explicitly represented and in detail. We have to distinguish between factors of production – as earners of the profits, wages and salaries – and the household sectors that own in various proportions the different types of labor and capital factors. The classification of households is of great importance in the determination of the type scenarios that are possible to analyze. (See Duchin (1999) for the derivation the mathematical relationships of price and quantity models and the central role of households for the analysis of scenarios involving the economic, social and environmental relationships)

In **Table 2** a schematic representation of a world SAM containing two regions 1.

Advanced Industrial Countries (AIC) and 2. Developing Countries (DC) is provided. The generalization to several regions is rather obvious.

Table 2. A Two Region SAM

		Activities		Factors		Institutions		Accumulation		Trade		Total
		1	2	1	2	1	2	1	2	1	2	
Activities	1	A1				C1		I1		E1		x1
	2		A2				C2		I2		E2	x2
Factors	1	F1										f1
	2		F2									f2
Institutions	1			W1		T1	T12					c1
	2				W2	T21	T2					c2
Accumulation	1					S1		K1	K12			i1
	2						S2	K21	K22			i2
Trade	1	M1								B1		r1
	2		M2								B2	r2
		x1’	x2’	f1’	f2’	c1’	c2’	i1’	i2’	r1’	r2’	

There are n sectors, k factors, m institutions, p types of accumulation and n traded sectors. The dimensions of the matrices are given below:

A:	nxn	x:	nx1
F:	kxn	f:	kx1
C:	nxm	c:	mx1
W:	mxk	I:	px1
T:	mxm	r:	scalar
I:	nxp		
S:	pxm		
K:	pxp		
E:	nx1		
M:	1xn		
B:	1xp		

Where:

- A1 and A2 are the IO matrices of intermediate use of AIC and DC respectively;
- C1 and C2 are the matrices of domestic consumption of AIC and DC by household group;
- I1 and I2 are the matrices of domestic investments of AIC and DC;
- E1, E2 are the exports vectors from AIC to DC and those of DC to AIC respectively;
- F1, F2 represent the earnings of factors of productions in AIC and DC;
- W1, W2 represent the allocation of income from factors of production to households in AIC and DC;
- T1 and T2 repersent the transfers between domestic institutions in AIC and DC; (redistribution of income).
- T12 and T21 are matrices of institutional income transfers from DC to AIC and from DC to AIC respectively
- S1 and S2, represent the savings in AIC and DC, by household groups;
- K1 and K2 represent changes in financial assets in AIC and DC;
- K12 and K21 are capital flows from DC to AIC and AIC to DC respectively
- M1, M2 are the imports by AIC from DC and from DC to AIC respectively;
- B1 and B2 represent the borrowing/lending to cover for the trade deficit/surplus of AIC and DC.

Note: In a 2-region world and of the sum of the components of B1 equals the negative of the sum of components of B2 as the total trade deficit of a region and its borrowing must exactly match the total trade surplus and lending of the other region. Similarly for K21 and K12, their scalar sum is equal to the negative of the other, since the net capital inflow of one region should equal the capital outflow of the other.

Moreover imports from one region and exports from the other region are equal in the aggregate but not as vectors because of different interpretation of exports and imports by sectors. Imports represent the import of all inputs by a given sector while exports refer to the export of the sector's particular product. Aslo note the alternative treatment that could distinguish between imports/exports according to whether they are for intermediate, final or accumulation sectors. In that case cross matricess like A12 and A21 have to be estimated for the first, C12 and C21 for trade in final goods and services and I12 and I21 for trade in capital goods.

In a SAM, consistency requires the equality of row and column sums such that the outlays and incomes are equated. In the table the vectors of row totals (last column) are transposed in the last row and represent the vectors of column sums.

What classification should we adopt? A simple classification for a basic representation of the flows in the world economy could include a scheme for Commodities consisting of: 1) Basic Needs (BN), 2) Non-renewable Resources (NR) and 3) Other manufactures and services (OTH), for households: 1) Poor (P) and 2) Rich (R) and for financial flows 1) Capital transfers (CT) and 2) Financial Assets (FA). Of course, this classification is extremely simplified and is used only to illustrate the kind of scheme that could inspire the elaboration of a world model. To analyze Production we could probably use both Countries, (Regions) and Products. In a simplified matrix, to analyze *Income* (and consumption and savings) we could probably use Countries and Household income levels. To analyze *Accumulation* we could again use Countries and a simplified classification of financial assets and liabilities. The reason for introducing Countries (regions) as a main category of agents in the system is to illustrate the point that, while problems might be global in nature, their institutional structures are geographically organized. In principle it seems possible to estimate these matrices at the aggregate level, used in this example, obviously with high levels of uncertainty, and to build therefore a very basic model of the world system. One could reasonably expect that it could be possible to extend the meso-economic level of detail for all the components of Matrix A.

Let us suppose that we have built a world SAM with these characteristics and that we have partitioned the system into endogenous (Production and Income) and exogenous components (Accumulation). In this case it will be possible to use the system as an extended I/O model relating financial flows (e.g. FDI and capital transfers) to production and income distribution. As production can be directly related to the environment, the output of the world model provides some indications about world sustainability (economic, social and environmental).

In some sense, this design of a world model is relating the financial sphere to the real sphere of the economy, one of the essential issues of today's world problematique (Fontela, 1998). But, from the point of view of futures research, the scenarios to be tested with the world model should go well beyond the values of flows of FDI or capital transfers, as these flows will in the end result from more complex situations implying different images of the world in all its possible dimensions (institutional, political technological, social, environmental, cultural, etc.).

Of course, a world SAM only portrays a given situation in time and the interest of the model increases when behavioral equations are introduced either to explain the process of equilibrium (the essence of Leontief's closed model) or the evolution in time of the system (the essence of Leontief's dynamic model), moving in this way towards the ideas of dynamic exploratory models or of general equilibrium models.

Let us suppose for a moment that the world model becomes a part of a wider Futures research programme. In this case, tentatively, we could envisage:

- to apply Delphi and morphological analysis to explore possible future technological developments affecting the Production system of the model;

  to apply Interpretive Structural Modeling (ISM, Warfield, 1976) in order to extract the relevance tree of the content of declarations made by observers of the world system (e.g. UN statements, Club of Rome, Group of Lisbon, political leaders, ILO, WTO, etc.);
- to use cross-impact analysis to measure a priori subjective probabilities by expert analysts, for political events at world level;
- to combine previous results into a comprehensive exercise of participative scenario writing (e.g. with consultation processes via Internet), including alternatives for policy making, and interacting with the world model.

Of course, other structures can be conceived for a world model and the description made above is only intended to open the scientific debate on this fundamental issue.

6.- Practical steps for the design of a New Generation World Model

Whatever the final design of a new global model, we are conscious of the fact that it is a complex, long term project requiring large financial resources, and extremely risky, specially if we attempt to build a tool for analysis, simulation and decision-making at world level.

Furthermore, we think that the modeling strategy should meet three basic requirements:

1. to promote participation, in order to integrate research from different countries and fields;
2. to use the full potential of new information technologies, as should be the case with a global project of innovating character (New Generation World Model)
3. to use the common interest in input-output approaches, with all their diversity

6.1.- The programme

On operational grounds we should envisage the following stages:

A: Putting forward and discussing the proposals
B: Delimitation of a first project and work programme
C: Design of the model (s)
D: Construction of the model (s)
E: First test runs
F: Applications, maintenance and up dating.

Without consideration of technical details, we comment hereafter these stages and their expected outputs.

<u>A: Proposals</u>

The Workshop Challenges of Global Modeling and the Special Session on Scenarios should constitute the starting point of a process including a six-month open forum in the web site of the IIOA, ending with a monograph in ESR. A list (open) of interested researchers in global modeling should be established. We suggest running also a series of workshop, on a periodic basis, dealing with the various IO and SAM based modeling traditions that will explore the relative strength and weaknesses of each with respect to the various aspect of the requirements of the world model and establish effective cooperation among them.

B: First project and working programme.

The analysis of options and proposals could lead to the selection (by one group of promoters) of a “project” to be circulated for comments and ideas for collaborative research. This “project” should support a more detailed proposal and programme to be used in order to gather the initial institutional and financial support.

It is difficult to estimate the time for this second phase, but we could expect it to cover one year, with some overlap with phase C.

C: Constructing the model:

Starting this new phase requires clear definition of research teams, organization and tasks, and sponsoring.

Depending on the selected option, this phase can require at least two years, but not more than 3-4 years. The diffusion of results (meetings, publications, internet news, …) will obviously depend on the support available.

E: Preliminary tests

A realistic program should consider that this phase could run several months after the end of phase C, even if it could possibly start before this stepping point.

F: Maintenance and application

We should be conscious since the beginning that it will take some five years to have a fully operational system of models, and that it would have to be periodically updated and extended. The viability of the project requires avoiding an excessive modeling complexity that could end with a system too heavy to maintain or to run when addressing concrete global issues.

6.2.- Organizational options

We don't consider that the New Generation World Model could be developed by a single team in a specific research unit. Rather we believe in a cooperative approach along the following **alternative paths**:

a: concentration of activities in a core team with subcontracting of component development

b: decentralization of functions in a network of teams sharing responsibilities;

c: network of teams structured by modules.

<u>A: Core Team</u>

A core team designs the structure of the model and organize also the applications. This core team raises the funds necessary for all the project and subcontracts other teams for the development of components of the global model.

HERMES (Harmonized Econometric Research Multisectorial and Energy System)- which includes IO tables - a project fully financed by the EC in the 1980's is a good example of this type of organization. The core team was at Lovaine Univ. (Belg.) and was in charge of subcontracting national teams (one in each EU country) for the estimation and updating of a model that was designed with a common basic structure, by the core team.

B: Decentralized functions in a network of teams sharing responsibilities

The strategic development of the project is, in this case, the final responsibility of a committee with representatives of all teams involved. Coordination is provided by one (or several) central team (s), but the results are of direct application by all teams.

Using common accepted norms, each team is responsible for the design, maintenance, up-dating and financing of a part of the global model (usually a country or region, or a theme).

An example of this type of organization is provided by LINK, today a UN project: it is run by a Council of representatives of the teams more heavily involved, and it is coordinated by a working group at the UN, another at the University of Pennsylvania and another at the University of Toronto; the later one is responsible for the maintenance of the project and provides tools for joint operational activities.

Financing of each model in the network is to be provided by each team, and it does not receive any financing from the coordinating groups except for travel to general meetings. The Toronto team has UN funds for a small research group devoted to the project; the national teams finance their activities in very different ways (sometimes inside, others calling upon national research grants, employers association, commercial forecasting services, etc.).

C: Structured networks

The complexity of the Next Generation World Model and the information technologies available suggest a new type of hierarchical structure, with chains of responsibilities, and an active and decentralized participation scheme.

In this alternative concept, the project is designed with modules leading to an assembly into a single model. These modules can be thematic, regional, and institutional in character and can integrate other more detailed (elementary) modules; teams working with full autonomy can be in charge of each module and/or elementary module, provided the commitment to integration with the rest of the system is effective.

As an example, an elementary module could be provided by each of the developers of I/O in different regions. Other modules could refer to income distributions, trade flows, capital flows, transfers, etc. Modules could also deal with expert opinions for the design of political, or technological scenarios, etc.

The organization in this case tries to help to design the set of modules that can be of interest (and application) by themselves, but can fit together into a “system of models”. In this way a large number of working teams could consolidate themselves institutionally and financially.

Coordination modules could help to integrate the single operational elementary modules, into more aggregated structures, leading to the world model.

In a way, the Next Generation World Model appears in this organization, as an integrative factor for new research teams working independently but with a shared goal.

We lean more towards this arrangement for the new model as it offers an innovative character and the flexibility required for the complexity of the task. (see the proposed structure in section 2.2 arguing for an open-source framework).

6.3.- Diffusion of results and institutional support

Diffusion and support are obviously different as a function of the organization structure adopted, but in any case it is good to consider two complementary lines for the working groups and for the functioning of the integrated project. Here we refer only to this second issue.

For diffusion we may consider:

1. a permanent workshop on Global Models at the IIOA meetings and possibly a preparatory workshop the years preceeding the IIOA meeting.
2. a monographic regular issue at ESR;
3. an agreement with a publisher for a book series;
4. a common logo providing some image of unity to otherwise dispersed efforts;
5. the creation and maintenance of web pages and links between them, in the framework of a common strategy.

As to institutional support, some options are the following:

1 Sponsoring by an international organization such as UN, WB, and IMF or by a large Foundation with international interests.

2 Setting a world network of sponsoring institutions with firms, foundations, etc. interested in globalisation

3 Looking for sponsors for each phase of the project during the period of construction of the system, and offer results under contract with the sponsors at different stages of the development

4 Creating a common fund with contributions from institutions backing each team working in the project.

These ideas in this paper are food for thought. The authors aim at launching the process of wider consultation, hoping to attract constructive criticism and a convergence of opinions over a few concrete ideas in the near future.

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