THE STRATEGY OF FUTURE REGIONAL ECONOMIC GROWTH

PROCEEDINGS OF A TASK FORCE MEETING ON REGIONAL DEVELOPMENT, APRIL 19-21, 1977

M. ALBEGOV, Editor

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PREFACE

Work related to regional problems was begun at IIASA a few years ago (1974) as part of the Management and Technology activities. The focus was mostly on the managerial aspects of planning, realization, and exploitation of large industrial complexes such as the Tennessee Valley Authority (TVA) in the USA, and the Bratsk-Illimsk Territorial Production Complex (BITPC) in the Soviet Union. The reason for these retrospective investigations was to collect and generalize on experience of the largest industrial projects carried out.

Natural development of these activities led not only to the analysis of industrial problems, but also to the study of very diverse regional economic problems. At the same time as this retrospective analysis, the feasibility of forecasting future growth was made, and the guiding of this process became very vital. In many of IIASA's publications integrated regional development (IRD) problems are described as one of the most urgent universal projects, and by universal one can include problems which reside within a single nation but are nonetheless of great importance for all countries.

The problem of regional development is so complicated, including so many questions for study and very often requiring the search for solutions under such controversial constraints, that there are nearly as many approaches as there are scholars involved in it. It was therefore very important from the outset to understand what was most important to be done in IRD and what should be done at IIASA by its international group of scholars. The majority of the reports presented at this meeting touched on these different problems. Of all the important questions discussed during the meeting, the following two need special mention:

- The problem of the quality of life and equality of access to services.

- The problem of the possibility of constructing a generalized system of models of regional economic planning.

The results of the discussions are represented briefly in the summary statement at the end of this report and they confirm the usefulness of organizing cooperative, international exploration of IRD problems.

Murat Albegov
July 1977

ABSTRACT

A Task Force Meeting was held by IIASA at Schloss Laxenburg, Austria, April 19–21, 1977, on integrated regional development (IRD). The main aim of this meeting was to clarify the possibilities of the generalization of international experience in studying the problem and to elaborate the corresponding mathematical tools.

A broad spectrum of regional problems, starting from theoretical analysis and ending with proposals for the organization of practical case studies, was discussed. The focus was on problems of feasibility of constructing a generalized system of models, interregional equality of access to services, and coordination between national and regional goals, among others. Also, the problems of interaction between IRD work and other IIASA activities (resources, human settlements, management problems) were brought up.

In the results of the discussions some conclusions on the development of theoretical analysis in parallel with practical work on mathematical models were made.

Contents

Welcoming Address

R.E. Levien

It is a pleasure to welcome you to IIASA. Before you turn to the specific topic of this meeting, I would like to provide you with some background information about IIASA, so that you can see how our interest in regional development fits into the whole.

Let me begin with the history of the Institute. At the end of 1966, the then President of the USA, Lyndon Johnson, proposed the establishment of an Institute that would serve as a bridge between East and West by working on common problems of industrial societies. He asked McGeorge Bundy, who had been his national security advisor, and was then the President of the Ford Foundation, to travel to Moscow to determine whether the Soviet Union was interested in pursuing this notion. There he met with Jermen Gvishiani, who is the Deputy Chairman of the State Committee on Science and Technology. The discussions were fruitful, leading to agreement that the Institute idea was a positive one. There then followed five years of negotiations in which an ever increasing number of nations were engaged. By 1972, two key agreements had been reached. First, 12 nations agreed to participate in IIASA, and second, it was agreed that the participation would be nongovernmental: rather than individual countries joining the Institute, the members would be scientific organizations from the countries. This institutional difference may seem narrowly legalistic, but it is an exceedingly important difference for the Institute. What 12 scientific organizations created in October 1972, was an international, but nongovernmental, research institution whose staff come not as representatives of their governments, but as individual scientists. They can therefore participate openly and freely in the activities of the Institute without feeling called upon to represent a political point of view. That means we can pursue work on relatively sensitive issues, involving scientists from countries with quite different social, economic, and political systems.

In June of 1973, work on the scientific program of the Institute began at the Schloss. More precisely, one scientist arrived--the first scientist. The first director of the Institute, Howard Raiffa, from the Harvard Business School, used to take visitors by that office, open the door, and say, "Here is a typical IIASA scientist at work". Well, statistically that is right; not only was he typical, he was <u>the</u> IIASA scientist. However, he was followed rather quickly by sixty colleagues and by September 1974 there was a full research program under way at the Institute--a fairly rapid growth of scientific staff.

Three years later, in May 1976, we had our first IIASA conference. This was an opportunity to sum-up the work at the Institute during the first three years, and to point out the directions of future work.

Now the first 12 National Member Organizations (NMOs) have been joined by five additional NMOs. These 17 organizations are Academies of Sciences or similar institutions. The Austrian Government has renovated and made available to us this marvelous Schloss. They charge us one Schilling a year as rent--and we are four years behind in our payments. The NMOs govern the Institute, through the IIASA Council, whose chairman is Jermen Gvishiani. He has held that position since the Institute's inception. The Council has one member from each NMO. They set the basic policy through renewing and approving the research plan and the budget, each year. The Council meets once a year, but the Executive Committee, Finance Committee, and Membership Committee meet more often. Andrei Bykov is the Secretary, a Council Officer, and also my Special Assistant for External Relations. The Director is responsible for the overall day-to-day management of the Institute, implementing the basic policies set by the Council. The Director has two deputies, Wolf Häfele of the FRG, and since last week, we were pleased to have Oleg Vasiliev from the USSR nominated as the second Deputy Director. The Institute has Scientific Services--meaning computing, publications, library--and an Administration, which takes care of the usual matters. But what you are more interested in, I am sure, are the research activities, and I shall turn to an explanation of those in a moment.

The basic funding of the Institute comes from the NMOs. There are two categories of NMOs: the United States and the Soviet Union are in Category A and each contribute 1.4 million dollars a year; all the other NMOs are in Category B, and they each contribute 216 thousand dollars a year. If your mental arithmatic is fast, you have totaled that up to 6.12 million dollars each year. Unfortunately, our founders did not have as much financial foresight as they might have, for they accepted dues in dollars, but then agreed to our location in Austria where the expenditures are in Schillings. At the time the Institute was founded, the dollar was at 23.18 Schillings; but now we have it at 16.8, so we have suffered a 30 percent decrease in Schilling income as a result of devaluation of the dollar.

To turn to the research program of the Institute, I would like to focus on two phrases of our title: International-Applied and Systems Analysis. I will tell you what each of those means for the Institute. "International-Applied" means that IIASA's role is first of all to address real problems of international importance. We distinguish two kinds of problems. The first we call global, which are those that inherently involve more than one nation. For example, problems of the global climate, problems of the oceans, problems of world trade; these cannot be resolved by the actions of individual member nations. It is obvious that IIASA can play an important role in studying such problems, because it is an international research institution, cutting across national boundaries. The second category, which is probably of more interest to you meeting here today, we call "universal" problems; these are problems which reside within single nations--for example, problems of regional development, health care systems planning, and transportation planning--but which all nations share. For this category, IIASA can play a role in the exchange of experience among countries. It can help nations to draw upon the methodological and practical experiences of other countries in solving their own problems. So Regional Development is a universal international problem. IIASA considers it an important part of its function to work on such problems.

The second phrase in our title is "Systems Analysis". This is a phrase that has many meanings and some might say, no meaning. We adopt a particular view of what "Systems Analysis" means at IIASA. To us it requires that we take a comprehensive approach to studying individual problems. I mean that when we look at an energy problem or an agricultural and food problem, we do not consider it as a single discipline might, but rather we see it through the eyes of many disciplines. And we look at it not as a single ministry might, but in its more complex institutional context in the real world. For example, in studying energy, we are interested in the resources available for energy production, in the environmental consequences of energy use in urban demands for energy, in health effects, in the management of energy systems, in alternative energy technology, and so on. This is a comprehensive approach, but obviously one that requires a careful drawing of appropriate boundaries. Thus, the essence of systems analysis at IIASA is to engage in a study of a major issue in a comprehensive manner, while also being careful to delineate reasonable and practical boundaries of the study.

What this view of IIASA's role implies for the Institute's research structure is a two-dimensional approach. Along one dimension, we have major Programs, which address issues of international importance. At the moment we have two such programs. The first is a global program on Energy, led by Wolf Häfele. It is looking at the future of global energy supply and demand, 15 to 50 years from now, and in particular trying to understand the transition from a global energy economy based on oil and gas to one based on nuclear, solar, coal, and other long-range, relatively inexhaustible, energy resources. That has been underway for three years and will finish by the end of 1978--at least its first phase.

The second program is our Food and Agriculture Program, led by Ferenc Rabar, which is just beginning. It is taking a broad look at global food supply and demand. Both of these issues are inherently global of character, although Food and Agriculture has a universal quality as well. One of the reasons we are meeting these two days, is to consider the possibility of establishing a third program, one of universal importance, in the field of Integrated Regional Development.

Each of these programs has an applied focus, finite lifetime, and particular goals. They mobilize a significant fraction of IIASA's resources and draw on a wide range of our skills.

Those skills come from the second dimension of IIASA's matrix, which we call our Research Areas. They represent pools of expertise. In our Resources and Environment Area, led by Oleg Vasiliev, we have experts in water resources, environmental questions, natural resources, and so on. In our Human Settlements and Services Area, led by Andrei Rogers, we have experts in human resources. These are specialists in population, in the location of population on the globe, and in its migration and settlement in urban areas, as well as delivery of particular services, such as health services. In the Management and Technology Area, led by Andrzej Straszak, we have specialists in organization, in physical technology, and in the economic system. And in the Systems and Decision Sciences Area, led by Michel Balinski, we have specialists in mathematical and computational tools for studying complex systems and decision problems.

The reason for the two-dimensional matrix is that we view these four Areas as pools of specialists who should be brought together in teams to study, for example, energy. So the Energy Program should draw upon the Resources and Environment Area for experts in natural resources, and in climate effects; on the Human Settlements and Services Area for experts on energy demand; on the Management and Technology Area for specialists in energy technology, and so on. This means that when we do a systems analysis, we need perhaps one or two systems analysts, or at most a small number of them, but a large number of specialists in specific aspects of the problem. Therefore, most of IIASA's staff are people who specialize in one of these specific areas. The result is our matrix structure.

The internal resources of the Institute are limited, especially when they are placed in conjunction with the ambitious program we have established. We have about seventy scientists paid by the NMOs here; the magnificent facilities supplied by Austria; and our library and computer. But as you can see, this is far too small an enterprise to carry out the program implied by this matrix structure.

However, IIASA never aspired to be, and has never operated as a self-contained research institution. Rather, the purpose of the Institute has been to have within the Schloss walls only the visible parts of a large international "invisible network", comprising people in all nations who are working on common problems. The 70 scientists paid for by our NMOs, therefore, are the core around which we place an expanding series of layers. In addition to the core we currently have several guest scholars--perhaps ten or twelve in total--who are paid by their home institutions. Some of these are industry, like Siemens, IBM, Shell, and some government agencies, like CNRS of France, and the UN, who are paying the salaries of their scientists while they work with us. These guests are important to us because they enable us to magnify our work, and also because they link us to their home institutions: to the industries, to the government agencies who send them. Furthermore, each year we have about one million dollars of external funds. These are monies that come from UN agencies, from foundations, and from governments. Presently we have money from UNEP; the Ford, Rockerfeller, and Volkswagen Foundations; from the Federal Republic of Germany's Ministry of Science and Technology, the Austrian National Bank, and so on. These external funds enable us to extend further what we could do with our seventy core scientists, to build up our research programs, to enable us to go in depth into areas where we could not otherwise go. They also serve to link us to certain decision-making bodies, like UNEP, and to provide the external validation of the work we are doing. But these three layers--core, guests, external funds--still represent work that is going on within the Schloss at Laxenburg. In addition to the 70 core scientists, the two other layers add 25 or so staff. Thus, at this moment, there are approximately 95 scientists working within the Schloss.

The largest addition to our effort comes through what we call "collaborative research". These are joint research activities undertaken with other research institutions, usually within the NMO countries. For example, in our Energy Program we are studying the coal option. We have allocated one or one and a half man years of effort to that issue here at the Schloss. But this small core group is linked with four other institutions: The National Coal Board in the UK, Ruhrcoal in the FRG, and with institutions in Poland and the USSR. Among these four other institutions there is considerably more manpower linked to the commonly organized and conducted study.

This kind of collaborative research vastly amplifies the ability of the Institute to accomplish its research aspirations. And it is one of the things we would like to talk about during the course of this meeting: in what ways might we establish collaboration with your institutions? Another way of amplifying our effort is through what we call "catalyzed research". This is work that get underway at an institution outside of IIASA, stimulated by work we have done, although it is not a part of our research program. For example, the National Center for Atmospheric Research in the USA has a program studying the climatological impact of carbon dioxide as a result of increases in burning coal and other fuels, that was stimulated by work begun here at IIASA. And finally, we have a major effort in "information exchange". Each year, for example, we engage in a conference on Global Modeling here; this year we will hold the fifth in this series. IIASA does not itself carry out global modeling in the sense of the Club of Rome exercises, having chosen rather to focus on individual sectors, like energy and food. However, we feel it useful and important to serve as an information exchange vehicle for those around the world who are working on global modeling, both those who are critical and those who are positively in its favor. So for the last four years we have held a series of conferences on the various global models, beginning with the Pestel-Mesarovic Model. Each year we hold about 40 workshops, task force meetings and conferences. This week, we have three workshops and conferences going on simultaneously. This is another way in which the core group of 70 scientists can amplify its influence and its effect, and reach a better balance between its ambition and its achievements.

This has necessarily been a brief introduction to the Institute. During the next four days we hope to obtain, through your work and suggestions, some solid ideas about how we might most effectively proceed with development of a program addressing the problem of integrated regional development. I want to extend my warm personal thanks to you at the very beginning, for coming and joining us, for what I know will be an intense and useful deliberation.

PRESENTATIONS BY MEMBERS OF IIASA'S IRD CORE GROUP

An Approach to the Sequence of IRD Problem Analysis

Murat Albegov

During the last few years, IIASA completed two retrospective large-scale regional analyses--of the Tennessee Valley Authority (TVA) in the United States and of the Bratsk-Ilimsk Territorial Production Complex (BITPC) in the Soviet Union. The results of these activities were discussed during special conferences at IIASA in 1974 and 1976. More about these and other exploratory work will be given in Professor A. Straszak's presentation.

At present, IIASA is developing prospective regional analyses. The reasons are that:

- Almost all IIASA's National Member Organizations (NMOs) estimate this problem as an important one for their countries,
- The problem is so complex that all international experience is needed to obtain practical results, and
- IIASA's internal matrix structure provides good possibilities for organizing genuine multidisciplinary work.

There are many studies and publications more or less concerned with integrated regional development (IRD) problems, but in such publications, the specific problem of the region under investigation is usually emphasized. That is why the possibility of exploring this problem as a universal one is so important.

One of the main tasks for an international institute, is to elaborate approaches, methodology, and software which can be used without any, or only minor, changes to solve a majority of the regional problems that NMO countries are faced with.

The opinions of the representatives at this meeting are most important for clarifying IIASA's IRD possibilities.

My opinion is that it would be effective to orient IIASA toward the elaboration of a universal IRD study. But so far, as for example in a very interesting report by Professor Sawaragi, a slightly different approach is taken and it would be useful to discuss this in more detail.

IIASA's term "integrated regional development" may be understood in various ways. By *development* one can understand movement in a desirable direction. A sharper definition and conceptualization is dependent on such factors as the previous history and/or present condition of the particular regional economy being studied. Thus it is clear that development must improve some aspects of the regional economy, but the kind of improvement to plan for and to stimulate depends on the main goals of the region's economic growth. For example, we can distinguish between industrialized and agricultural regions, rapidly developing and stagnating regions, regions with productive and nonproductive specialization, regions which suffer from shortages of labor, energy, water, and so on.

Although there is no generally accepted definition of *regional*, there exist many bases for classification. Thus, during this meeting, it would be better to understand region as a part of the territory with the same problem (or number of problems) to solve. Generally speaking, it will be simpler to consider territories within national boundaries including rural areas as well as towns. Thus, to constrain investigations to national boundaries entails an important simplification of the task; for special cases, however, multinational problems might be the focus of IRD activities. One good example of this is proposed by Professor Domanski.

By *integrated* one can understand not only a simple interlinkage between separate parts of a regional economy but a kind of unifying of the different sectors of the regional economy to provide us with new qualities giving additional economic efficiency. The effect of agglomerations may be pointed out as an example of this sort of new quality.

The purpose of our meeting is to establish the important aims and tasks of IRD research at an international level, and IIASA's role therein: the problems to be solved and the main ideas which deserve to be developed, possibilities of engaging in more interesting case studies, and the possible role of the NMOs in IIASA's IRD exploration. Taking account of these main goals of our meeting, I will talk of the experience of the formulation and implementation of IRD models in countries with centrally planned economies, in particular, the Soviet Union.

In the first part of my report, I want to discuss briefly some aspects of analysis of theoretical problems of IRD. It is clear that the majority of these problems are not yet solved. For example, it is possible to start with the problem of regional classification. What are the economic relations between whole countries and their region? Are the regional economies only dependent parts of the national economy, or do they have their own, maybe controversial, goals? Who formulates the goals of regional growth, and how, when regions have their own aims of development? How does one coordinate a so-called program-oriented approach to the growth of a regional economy with the development of the country's economy? How does one best estimate the extent to which a particular region has fulfilled its economic, social, political, and other requirements? The ways in which such problems are approached and resolved have a direct influence on IRD explorations. For example, the attempt to estimate the consequences of social, and political requirements involves a multicriteria approach.

IIASA could start with an exploration of one of the very important theoretical problems, and wait for the results. But more appropriate is to combine the theoretical explorations with practical implementation, in which the application uses all available theoretical achievements. As I have tried to suggest to you, IRD problems are so complicated and multifaceted that it is difficult even to find a starting point. Many important problems are tied in one chain.

I will start, as we usually do in countries with a centrally planned economy, from the point of view of specialization of the region. And for this, we can discuss three main approaches. Firstly, to consider a submodel within the national systems of models. Secondly, to use a production-function linked approach. Thirdly, to construct a special regional model that maximizes the region's own objective function and uses external information. Now I will discuss these approaches.

The first system of models to include regional models in the Soviet Union was elaborated by the Institute of Economics and Industrial Management of the Siberian Branch of the Academy of Sciences of the USSR. This Institute is headed by Academician Aganbegyan, and the system developed includes a first stage of calculation and estimation of the country's economy as a whole, interregional-intersectoral optimization models, and then the block of models which concern regional optimization and optimization with respect to branches of industry (Figure 1). I want only to emphasize, in this system of models, the coordination procedure between the main blocks. It is not easy to realize this approach, and the interregional-intersectoral optimization models are quite aggregated; that is why it is not so simple to obtain useful results. Hence many research institutes in our country, including my own, are engaged in investigation using other approaches.

First national-level estimates are made, and then immediately afterwords, analysis of individual industries beginning with the extractive industries (Figure 2). There follows the problem of allocation of resources of special kinds, to be discussed later, and the regional optimization model.

What may be emphasized in this kind of model? The system is based on dual estimates, which can be calculated during the second stage. Nonlinear dependencies upon resources are included as a function of the volume of consumption. A few resources are included in block 3, and if we then go to a subregional economic level, you see that only at one point do we have this arrow back and forth. So we do not need to spend too much time on coordination problems. In the last part of the diagram, you see a special block for the largest industrial plants and complexes. Why do we separate this block? Because the objective function of the main parts of this system is minimized. During this calculation, one

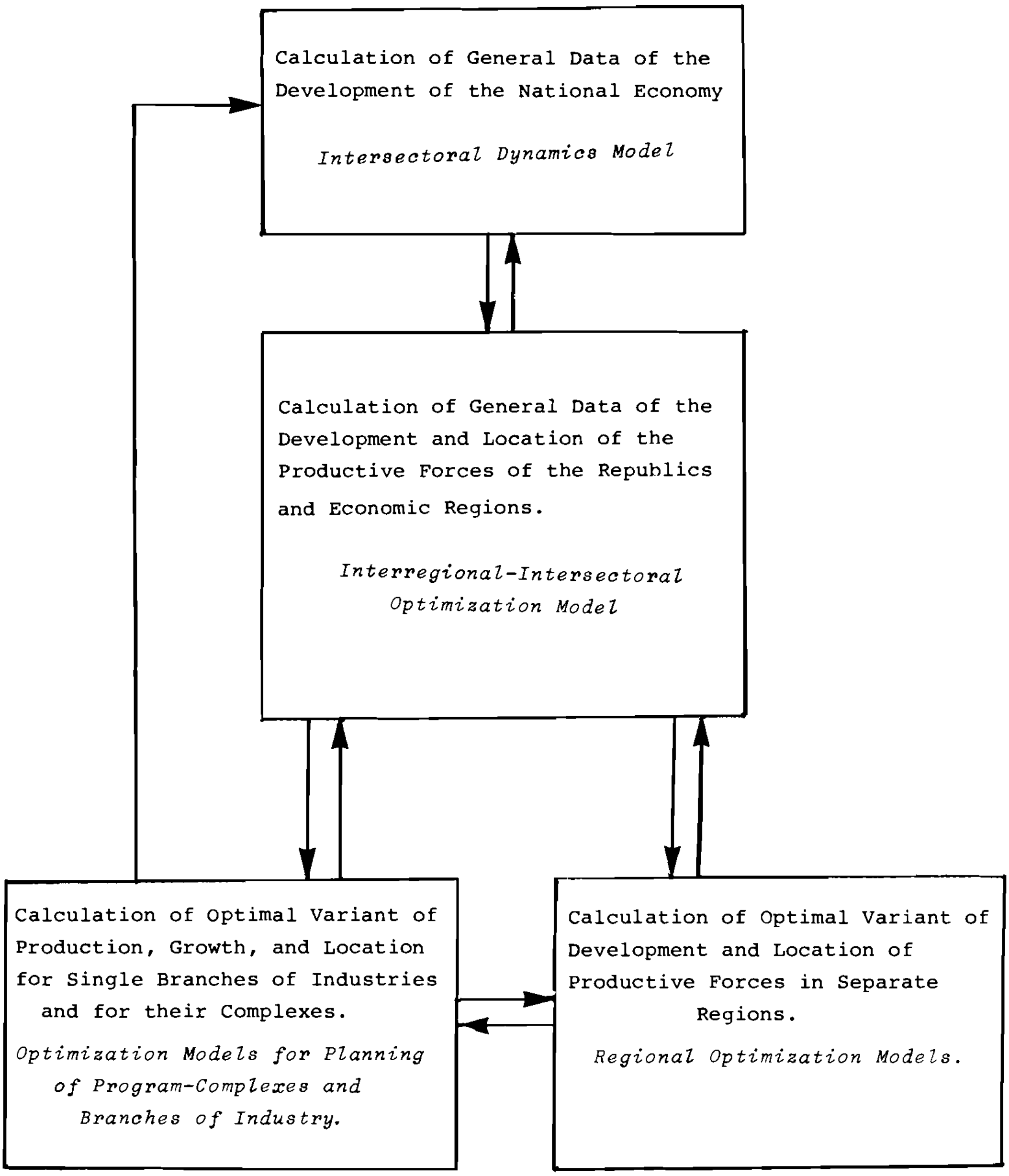

Figure 1. Sequence of models for territorial-industrial planning (Novosibirsk variant).

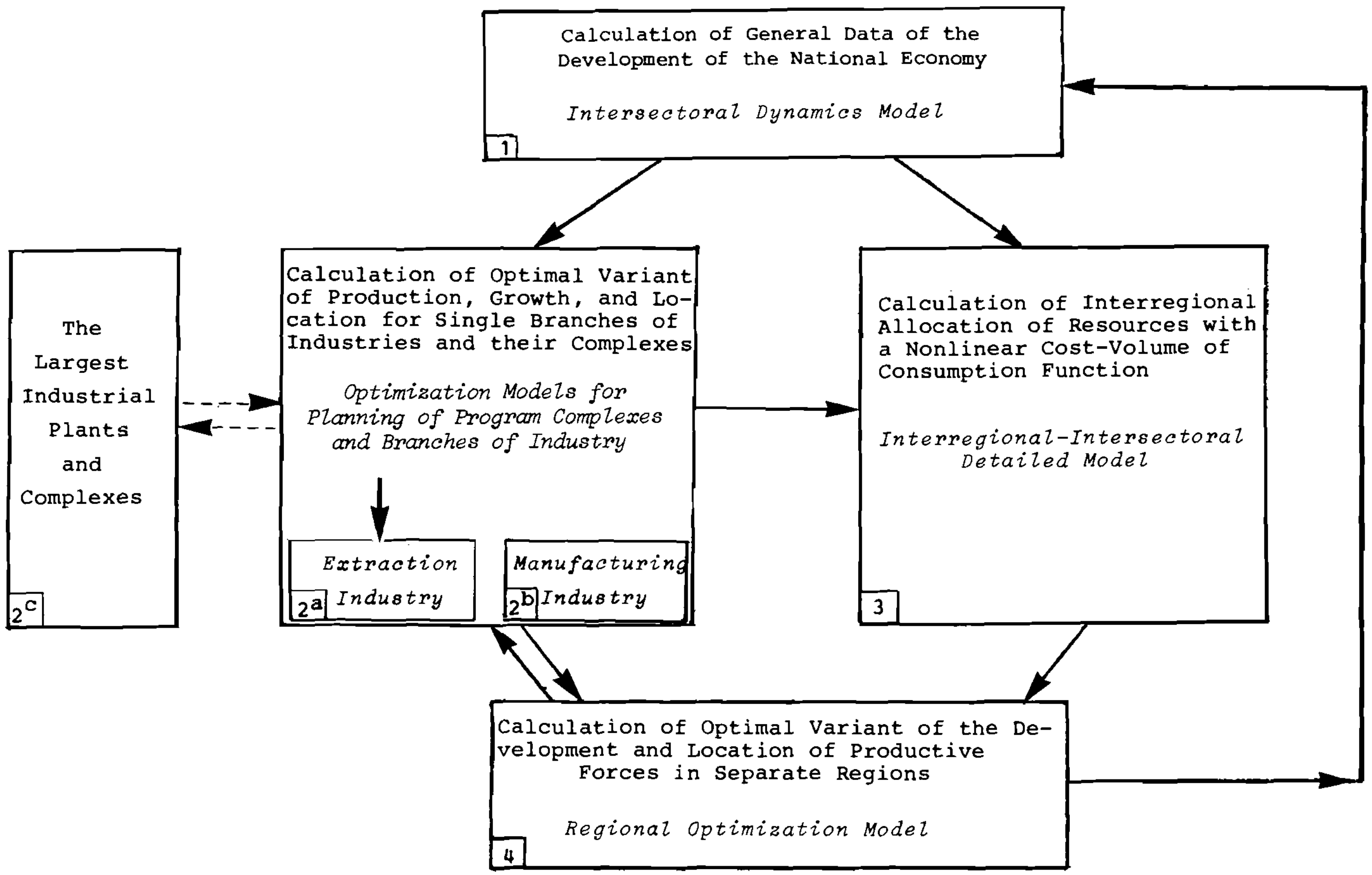

Figure 2. Sequence of models for territorial-industrial planning (CLPF-variant).

obtains additional information concerning the estimation of resources which can then be included in the next block. The next part (block 2e) is a special block for big industrial plants that use these dual estimates and that are oriented towards maximizing their objective functions, resulting in industrial complexes.

We have had satisfactory experience with the elaboration and implementation of these dual estimates. For example, two years ago at IIASA, a special report on a simple model of energy balance was presented in which a system of dual estimates was elaborated for each kind of fuel (natural gas, oil, hard coal, brown coal, etc.) (Table 1). As a combined system of dual estimates, all the data in each region for each fuel are collected. There is no possibility of increasing one without influencing the others. All of them, as part of one system, go up and down at the same time, depending on the fuel situation in the country as a whole, and on exports and imports. We have also had some practice in elaborating dual estimates for water resources (Table 2).

The system of models is oriented to the methods of so-called reaction functions used for the analysis of interregional-intersectoral problems. A special model of "allocation of local resources" was implemented and I want to emphasize the first part of its objective function. This includes the deviation of sectoral expenditures in comparison with the sectoral optimal plan (Table 3). This makes it possible to reduce the amount of information necessary so that at the next level only those data (Δmin) corresponding to the increase of sectoral expenditure are needed when one tries to implement a decision that is contrary to the optimal decision for this particular industry. It may be with this approach that we can go to an optimal decisionmaking procedure for the country as a whole.

The method makes possible the representation in a very concise form the results of all kinds of optimization solutions of particular branches of the industry and of particular regions.

The second approach to the problem is oriented to the continuous-substitution type of production function often used in investigations, although not in my country. I suppose the general idea of IRD is that something is wrong in a region, and that is why we try to investigate it; if the root of the problem is economic, we try to improve the economic decisions for this region. The approach is some kind of extrapolation of previous trends into the future. My feeling is that this approach should be considered in some of our IIASA investigations, but should not be the main way of analyzing the problems.

The third approach is to use experience gained in my country. For example, when one investigates the structure of industrial complexes, it is possible to use the dynamic model shown in Table 4. In this model we can introduce an objective function based on dual estimates, and expenditures of enterprises. Maximization problems can be tackled and the structure of the industry, agriculture, and service specialization of the region can be chosen at will.

Table 1. Model for fuel marginal price estimation.

Primary Task

$$\sum_{ij} c_{ij} x_{ij} \longrightarrow \min \quad ,$$

subject to

$$\sum_{j} x_{ij} \leq A_i \quad ,$$

$$\sum_{ij} \lambda_{ij} x_{ij} = B_j \quad ,$$

$$x_{ij} \geq 0 \quad .$$

Dual Task

$$\sum_{j} Y_j \nu_j - \sum_{i} a_i u_i \longrightarrow \max \quad ,$$

subject to

$$\lambda_{ij} \nu_j - u_i \leq c_{ij} \quad ,$$

$$u_i \geq 0 \quad .$$

*Examples of Results of Calculations**

Region		Natural Gas	Oil	Hard Coal		Brown Coal from Kansk-Achinsk
				Out-of-mine	Sized	
1.	Northwest	23-26	22-25	22-24	23-25	-
2.	Komi SR	17-20	16-19	14-16	15-18	-
3.	Northern Caucasus	21-23	20-22	20-22	21-23	-
4.	Volga Basin	21-23	20-22	19-21	20-22	-
5.	Southern Urals	19-21	17-20	15-17	16-19	-
6.	Novosibirsk	15-18	14-17	10-13	12-14	8-10
7.	Krasnoyarsk territory	-	15-17	10-12	12-13	2.5-3.5
8.	Primorsk territory	-	19-21	16-18	17-19	-
9.	Western Ukraine	23-26	22-25	21-23	22-24	-
10.	Byelorussia, Lithuania	24-27	23-26	22-24	23-25	-
11.	Georgia	21-24	20-23	21-23	22-24	-
12.	Uzbekistan	15-17	14-16	14-16	15-18	-

*All calculations (rubles per tonne of coal equivalent) were completed before the energy crisis; now these estimates would be higher.

Table 2. Marginal cost estimates of water-management areas of the European part of the USSR (in kopecks per cubic meter by forecast periods).

Source: Podolsky, Y.M. and A.Y. Florov (1973), "The Choice of an Optimal Scheme for the Regulation of Runoff in a River Basin," *Proceedings of Gidropoekt*, *29*, Moscow.

Management Area	*I*	*II*	*III*
Caspian Sea Basin			
1. Caspian, Lower Volga	0.2	0.8	1.7
2. Middle Volga, Oka. Kama	0.4	0.9	1.8
3. Upper Volga	0.4	2.8	2.8
4. Moscow	2.0	3.8	3.8
5. Upper Oka	0.4	1.4	2.3
6. Tula	3.3	3.8	4.7
7. Upper Pechora	0	0	1.2
8. Upper Vychegda	0	0	1.0
9. Sukhona	0	0	0.6
10. Upper Onega and Sukhona	0	0	1.0
11. Lake Onega	0	0	0
12. Upper Ufa	0.4	6.0	12.1
13. Upper Chusovaya	0.4	11.0	22.7
14. Volga-Ural interfluve	5.2	5.8	6.7
15. Lower Ural	0.2	1.3	6.7
16. Middle Ural	0.2	1.7	6.7
(a) Aktyubinsk	5.2	5.8	6.7
(b) Kumak	13.2*	13.8*	14.7*
17. Upper Ural	5.1*	5.7*	6.7*
18. North Kalmyk	––	3.8	4.7
19. South Kalmyk	0.2*	5.8	6.7
20. Terek-Kuma	0.2	1.0	4.0
21. Dar'yal	0.3	1.2	5.0
22. Sulak	0.2	1.0	2.0
23. Izberbash	1.0	3.0	5.9
24. Samur	0.2	0.8	4.7
25. Baku-Apsheron	6.0	16.0	20.0
Azov Sea Basin			
26. Azov Sea and Don	0.2	2.3	3.2
27. Sal'sk	0.7	2.8	3.7
28. Kagal'nik	0.2*	4.8	5.7
29. Chelbas, Yeya	0.2*	5.8	6.7
30. Lower Kuban'	0.7	6.8	7.7
31. Upper Kuban'	0.7	8.9	9.8
32. Yegorlyk	4.2	11.4	13.3
33. Kalaus	3.9	13.1	14.0
34. Yergeni	––	5.3	6.2
35. Upper Don	3.3	3.8	4.7
36. Northern Donets	5.2	6.1	8.0
37. Kursk Magnetic Anomaly	6.6	7.1	8.0
38. Khar'kov	8.2	9.1	11.0
39. Donets Basin	25.2	26.1	28.0

Management Area	*I*	*II*	*III*
Black Sea Basin			
40. Lower Dnieper	0	0.9	2.8
41. Upper Dnieper	0.3	1.2	3.1
42. Minsk	––	1.2	4.0
43. Il'men'	0	0	0
44. Perekop	0.1	2.5	4.4
45. Central Crimea	0.1	5.4	7.3
46. Feodosiya	5.3	10.0	12.0
47. Kerch'	9.4	14.0	16.0
48. West Crimea	11.8*	12.7	14.5
49. South Crimea	15.0*	16.0	18.0
50. Melitopol'	4.5	5.4	7.3
51. Ingul-Ingulets	2.0*	17.3	19.2
52. Southern Bug	0*	1.2	6.0
53. Dniester-Southern Bug interfluve			
(a) Dniester zone	––	6.8	11.0
(b) Southern Bug zone	0*	12.5	17.3
54. Lower Dniester	––	2.6	2.6
55. Upper Dniester	––	2.6	6.0
56. Lower Danube	0	0	1.2
57. Upper Danube	0	4.0	4.0
58. Prut	0	2.1	2.1
Ob' Basin (Volga zone of influence)			
59. Chelyabinsk	3.0*	6.0	12.0
60. Sverdlovsk	5.0*	11.0	23.0
Transcaucasia			
61. Kura-Araks	0.3	3.0	5.0
62. Pirsagat	3.0	6.0	9.0
63. Alazan'	0.3	8.0	12.0
64. Tbilisi, Iori	0.5	4.0	7.0
65. Tskhinvali	4.0	5.0	7.0
66. Khrami, Debed	1.0	5.0	8.0
67. Vorotan, Nakhichevan'	1.0	5.0	6.0
68. Sevan	5.5	6.5	7.5
69. Akhuryan	0.1	5.0	7.0
70. Lenkoran'	8.0	9.0	10.0
71. Black Sea coastal basins	0	0	0

Note: (*) Very limited water resources
–– No disposable resources

Table 3. Allocation of "local" resources.

$$\sum_{m}\sum_{n=1}^{N^1} \Delta F_{mn} X_{mn} + \sum_{m}\sum_{n=N+1}^{N} (C_{mn} + T_{mn}) X_{mn} + \sum_{m,k,\ell} Z^K_{ml} \cdot r^K_{ml} \longrightarrow \min \quad ,$$

subject to

(1) $\sum_{m} X_{mn} = \beta_n \quad ,$

(2) $\sum_{n} \gamma K_{mn} X_{mn} \leq \sum_{\ell} R^K_{m\ell} \quad ,$

(3) $0 \leq r^K_{m\ell} \leq R^K_{m\ell} \quad ,$

(4) $0 \leq X_{mn} \leq A_{mn} \quad ;$

where:

m are regions, n, sectors, K, the kind of resources,

A_m, the vector of maximum output,

β, the vector of consumption for the country as a whole,

γ^k_m, the vector of consumption of resources (per unit of production),

R_m, the vector of maximum of available resources,

ℓ, the number of plots which linearize the function $Z(r)$,

$Z^K_{m\ell}$, the cost of unit of resource (restricted by $R^K_{m\ell}$),

ΔF_{mn}, the average increase of sectoral expenditures in the case of changing turnout of production "n" in region "m",

C_{mn}, the cost of production,

T_{mn}, the location rent,

N^1, the number of sectors which are needed in the special modeling of their growth and location, and

$N^1 + 1,\ldots,N$, the number of other sectors.

Table 4. Dynamic model of industrial complex.

$$\Phi = \sum_{t,n,m} \beta_t (U^t_{nm} - Z^t_{nm}) X^t_{nm} A_{nm} \longrightarrow \max \quad ,$$

subject to:

$$\sum_n A_{nm} X^t_{nm} \gamma^{Kt}_{nm} \leq S^{Kt}_m \quad , \qquad \text{for all K, m, and t} \quad ,$$

$$\sum_m A_{nm} X^t_{nm} \geq \underline{\beta}^t_n \geq 0 \quad , \qquad \text{for all n and t} \quad ,$$

$$\sum_m A_{nm} X^t_{nm} \leq \bar{\beta}^t_n \quad , \qquad \text{for all n and t} \quad ,$$

where

m are points, n, products, K, resources, t, the time,

A_{nm}, the vector of the volume of production which can be considered as 100 percent,

γ^{Kt}_n, the vector of technological coefficients,

$\underline{\beta}^t, \bar{\beta}^t$, the vectors of minimum (maximum) possible production of a complex under consideration in the year t,

Z^t_m, the vector of the costs of production,

U^t_m, the vector of dual estimates,

β_t, the discount coefficient,

S^{Kt}, the vector of the maximum possible consumption of resources K in year t, and

X^t_m, the optimized vector of density of production at point m in year t.

How should the main goals of IRD be formulated? I suppose that our main aim will be the ambitious one of elaborating a universal system of models enabling the solution of the majority of the tasks of IRD, and providing competent authorities with a basis for decisionmaking--i.e. to supply them with the results of calculations, with the characteristics of all the more important variants of regional growth, including any social, economic, and other constraints, allowed for.

What kind of system of models should we introduce? We can start with the next system of regional models shown in Figure 3.

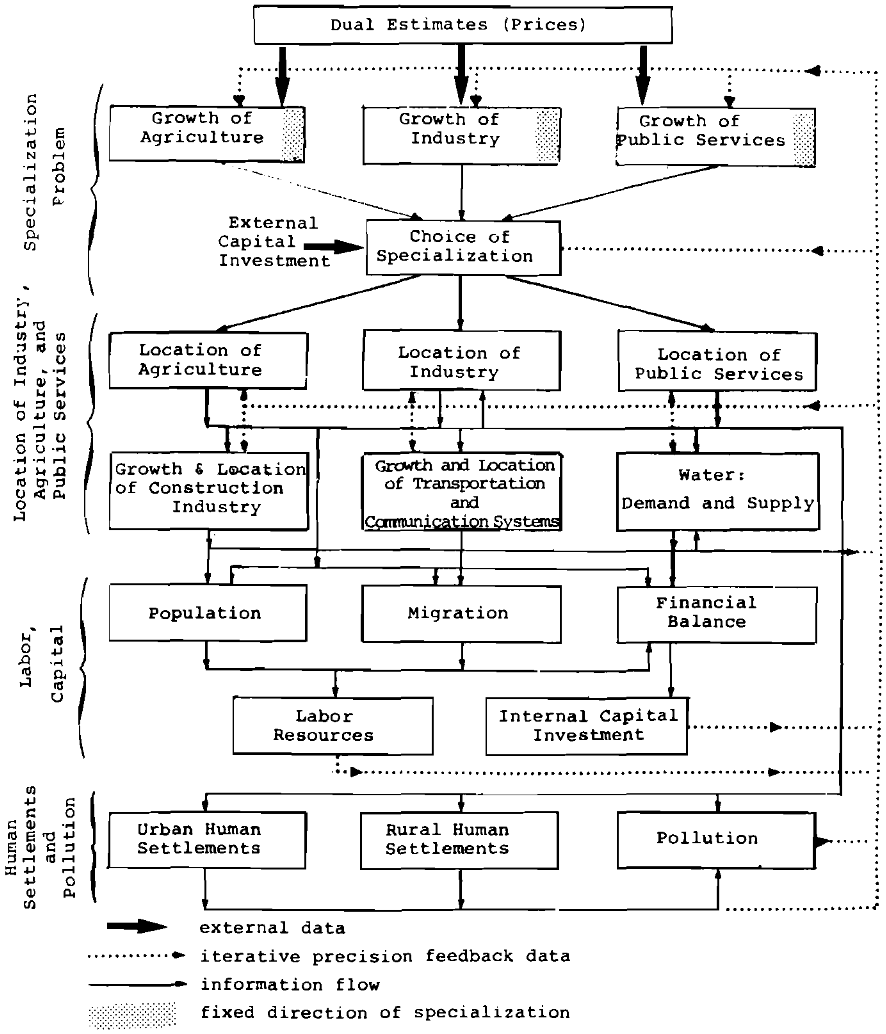

Figure 3. Preliminary scheme of the IRD study.

The first level will be the choice of specialization of the region between such sectors as agriculture, industry, and public service specialization. (All sectors are considered in detail.) The approach to such problems of choice may differ in different regions. For example, in my country now, we do not estimate the growth in the public service sector in monetary units so a fixed-coefficient approach to this part of our economy is used. In the regions of other countries, a monetary estimation of the results of the growth of the public service sector can be used. The three first blocks can then use the same reaction function approach as I discussed earlier for their combination.

The second level is the location of agriculture, industry, public services, construction industry, transportation and communication system, and water supply system. The third level is the problem of population, migration, and labor resources. The problem of capital investment is the final level. The relations between these blocks are logical because, for example, the estimation of the population size requires knowledge of the efficiency of agriculture, industry, or services: salaries and wages in a region might be increased. There would then be migration to this region. The individual points of our region are next considered: the problems of settlements, pollution, and so on.

I will finish by emphasizing that if we unify our forces, combine all our possibilities, and utilize the achievements of the NMO countries, we can start working with this problem. The first step may be to evaluate the state of the art; next, elaborate an approach; and maybe immediately thereafter start with a good case study.

IRD: Efficiency Versus Equity With Some Suggestions For Descriptive Research

Roland Artle

> Universal programs address issues that lie within national boundaries and that can, in principle, be resolved by the actions of decision makers within each nation. Their universality lies in the fact that all (or almost all) nations face the same issues. The design and management of national health care systems, transportation systems, or regional development programs are examples of universal issues. The major universal issue to which IIASA should devote its long-term attention is integrated development within nations. In contrast to the common situation in which development in one or several sectors of a society occurs without due regard for the consequences in other sectors or recognition of the need for their complementary development, the phrase "integrated development" denotes a situation in which planning and implementation are multisectoral; intersectoral effects are anticipated and exploited; and benefits and costs are balanced across the interrelated sectors. Thus, in integrated development the extension of industry is planned in conjunction with protection of the environment, provision and preservation of water and other natural resources, satisfactory settlements and services for the population, and so on. Like the attempt to comprehend future global development, the quest to achieve integrated development is an exceptionally difficult, possibly unending, one. It cannot be attacked in a single step, but must be approached instead through a series of incremental improvements, each building on the preceding ones. (From IIASA Research Plan, 1977)

In the first part of this brief paper, I wish to share with you some of the experience gained in Swedish economic planning and modeling at the regional level. At least in spirit and intent, the Swedish approach has been to proceed "through a series of incremental improvements, each building on the preceding ones". The concern has been very much with an "integrated development", as interpreted in the IIASA Research Plan quoted above. But before I engage in a discussion of the Swedish experience, allow me to make some personal observations.

I have now spent about two weeks at IIASA, and during this period I have had the opportunity to review some of the work done in the Resources and Environment Area, especially with respect to energy and water; in the Human Settlements and Services Area; in the Management and Technology Area; and in the System and Decision Sciences Area. To the extent that the work reviewed in these various Areas has dealt with (normative) economic modeling, it has struck me that the studies have almost invariably been formulated in the terms of one objective or criterion, namely economic efficiency--to the almost complete neglect of other criteria.

To a considerable extent, such an orientation and emphasis is inherent in the mathematical techniques utilized: the "Lagrangian multipliers", the "dual" variables, the "costate" variables in dynamic analysis, all have appealing economic interpretations as efficiency prices ("shadow prices", etc.). In comparison, conceivable alternative, or complementary, criteria are often very elusive.

There is also another reason, I suggest, why the work done at IIASA seems so overwhelmingly geared towards economic efficiency, namely its macro-orientation. When modeling is done at the micro-level--at the level of the individual, or the household or family--the context lends itself more naturally for a consideration of other criteria (in addition to efficiency).

Lest I be misunderstood on these two points, I certainly see the very great importance of the criterion of efficiency, and the great significance and scientific value of macro-modeling. It is the exclusivity of emphasis on these particular ways of "looking at the world" that concerns me. In a perhaps fumbling attempt to engage you in debate on both these points, I have chosen to devote this discussion paper to some of the alternatives. In the first part, I shall focus my discussion of the Swedish experience on its concern with the criterion of (distributional) equity.* In the second part of the paper, I shall sketch out some micro-oriented research possibilities in the area of integrated regional development (IRD).

As in most countries with some form of national economic planning, Swedish planning proceeds in stages.

(1) Using the long-range plan for 1980 (and prepared in 1970) as an example, we have a first stage which allocates resources to such broad national categories as household consumption, government consumption, private capital investment, public capital investment, exports, and imports.

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*For a rich and perceptive discussion of notions of equity in the regional and local contexts, see Stöhr and Tödtling (1976).

(2) The next stage specifies production targets for different industrial sectors (with input-output analyses used as a means for checking internal consistency).

(3) The third stage provides a regional distribution of population and labor.

(4a) The question now arises: How can the compatibility between stages (2) and (3) be analyzed? Assuming that the relevant feasible space--defined such that the target values in (2) and (3) are realized--is nonempty, how can equity considerations guide policy? Insight has been provided by Ohlsson and Granholm (1972, 1974; Granholm and Ohlsson, 1975).

(4b) They use a linear model which minimizes (national) capital investment over the planning period. Sector- and region-specific marginal capital-output ratios and labor-output ratios are utilized. (Eight industrial sectors and 24 regions are specified.)

(4c) The target values for sectoral outputs (national) and for the regional distribution of labor are specified as constraints. Based on data for a recent 15-year period, upper and lower bounds for the regional employment levels in each sector are also specified.

(4d) The optimal solution is calculated from (4b) and (4c). This is called the efficiency solution, from which two extremal values-added-per-worker are recorded, namely, the value added in the region with the highest value-added-per-worker (y_{max}) and the value added in the region with the lowest value-added-per-worker (y_{min}).

(4e) The difference between the two, u ($= y_{max} - y_{min}$), is taken as a measure of the regional inequality gap. Now, by gradually reducing the inequality gap a curve can be traced out in an "equity-efficiency" space, in which u is measured along one axis, and the corresponding minimum capital investments (I_{min}) on the other (see Figure 1).

As can be seen, a fairly substantial equalization in per capita income across regions can occur at a relatively small increase in national capital investment (movement from point Ef to point Eq in Figure 1). On the other hand, if equalization is pushed beyond Eq, the capital investments rise rapidly, at minute gains in equity.

The goal of an equitable income--or, more broadly, an equitable welfare--distribution has had a high priority in Swedish

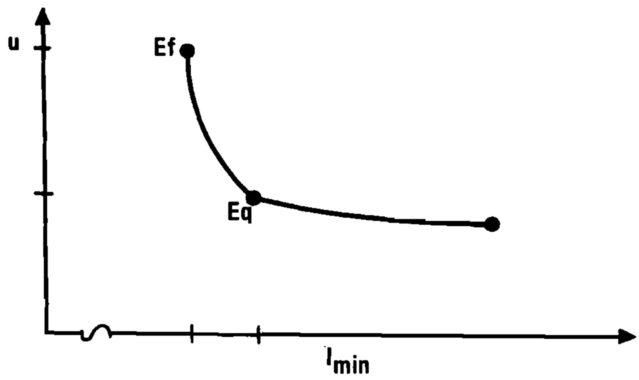

Figure 1. Illustration of the trade-off between efficiency and equity.

regional policy (Hansen, 1974; Ohlsson, 1976). The means to achieve this goal have largely consisted of subsidies and loans to individuals (to increase their mobility, in the sense of physical as well as job mobility, for example by way of retraining grants); to business firms (in order to create new employment opportunities in lagging regions); and to local and regional government agencies (for instance, to support actions of environmental protection and to support the provision of vital services). Such subsidies and loans have been provided to large numbers of recipients and usually in fairly small amounts. Hence, there has been a high degree of dispersion, or scatter, in these regional policy actions. More concentrated measures have, however, also been taken--e.g. various government agencies have been relocated away from Stockholm, several regional "branches" of universities have been established. The past few years have witnessed the emergence of an even more concentrated effort, the so-called "Steelwork 80", to be established in Lulea, a town located near the northern tip of the Baltic Sea. It would employ some 2700 steelworkers and altogether, including the indirect and induced employment effects, well over 5000 new jobs would be created. Lulea is located in a province where the unemployment rate is two to three times higher than the national rate, and the province is small enough for the creation of 5000 new jobs to have a substantial impact. By international standards, this project is not very large, but it seems to have much of the flavor of the IRD projects contemplated for study at IIASA. Hence, a few words about some of the issues and problems surrounding the Swedish project may be of interest.

One rationale for the Lulea project has been to create a viable and attractive alternative to "life in the metropolis". With the influx of new industry, with the increased population and income base, it has been argued, more choice for the individual could be provided, with a richer provision of private as well as public services. However, as Lennart Ohlsson notes in his assessment of Swedish regional policy cited above, there is at times a conflict between the employment and the income goals: providing more jobs in a particular region can lead to increased regional disparities in income or welfare. This seems to have become an issue in the Lulea case. Building a new steel mill (there already exists an older ironworks in the area) it is suggested, will essentially have a quantitative impact, attracting workers with skills similar to those that the region already possesses. A steel mill, it is said, cannot provide the diversity and the multifaceted development hoped for, by virtue of its technological structure. The fear has been expressed that many of the workers will come not from Stockholm or other areas in the south, but from smaller communities and rural areas in the Lulea province, thus further eroding their population base for future service provision.

These are some of the issues discussed by planners, geographers, demographers, economists, and political scientists, with regard to the "Steelwork 80"--and there is a risk that these discussions may literally remain academic. The construction of this government-owned steel plant is now in doubt, or at least postponed. Ostensibly, the chief executive of the project has resigned due to disagreements over the pricing policies of another government-owned corporation, namely the supplier of the iron ore. Deeper economic reasons, however, must have played a large part in the postponement. Since 1973--and with the obvious exception of capital investments in energy-producing resources--the global set of economic capital investment projects has shrunk. To see the reason behind this reduction in the opportunity set, one must recall that there is a strong complementary relation between capital and energy. The steep rise in energy prices has therefore been accompanied by a worldwide curtailment in the demand for capital investments.

In conclusion, let me describe three regionally oriented research problems, concerning which our learned and distinguished visitors may be able to advise us.

1. There is an affinity between "equity" and the notion of "equal access".* In a regional or local context, the notion of "access" may be slightly more tractable than the notion of "equity". By an agent's "access", we mean here "potential use".**

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*When Professor Domański in his paper states as a primary objective of regional development the elimination of "interregional differences in people's chances of (their) life-time", it seems to me that he has the notion of access in mind.

**We associate "access" with an agent, such as an individual, a household, or a firm. The related work "accessibility" is used to measure a distance relation between (spatially distinct) points.

A difficulty with the concept of access is that there exists as yet no fully satisfactory linkage between this concept and any existing theory. For example, in (nonspatial) economic theory, the notion of access has no role. It is conveniently assumed that markets function adequately, with the important implication that everyone has equal access to all markets. In turn, this implication has far-reaching consequences, among which I shall here point to only the following: it justifies the procedures of every "benefit-cost" or "efficiency-cost" analysis of public projects in which only the actual users of the project are considered.

Access depends very much on the time constraints, as well as income limitations, facing the individual household and its members. This has been stressed for a long time by planners and geographers, perhaps especially T. Hagerstrand (1973, 1974). But there has not emerged any satisfactory conceptualization of this aspect. In some contexts, access has an important "systems" or "sharing and interaction" aspect. Access to a system (say, a health care system, a transportation system, a telephone system, or a university) provides an individual with a set of opportunities which depends upon the number of other individuals who also have access to it. This aspect has been modeled for a telephone system (Artle and Averous, 1977).

What is the relevance of access in the context of IRD? One answer is this: it can provide a fruitful "diversion" from our present preoccupation with macro-oriented models. A starting point for research in this direction is the analysis of the individual's (and household's) use of time. The time relationships between a birth and future access requirements are captured in a simple diagram (Figure 2):

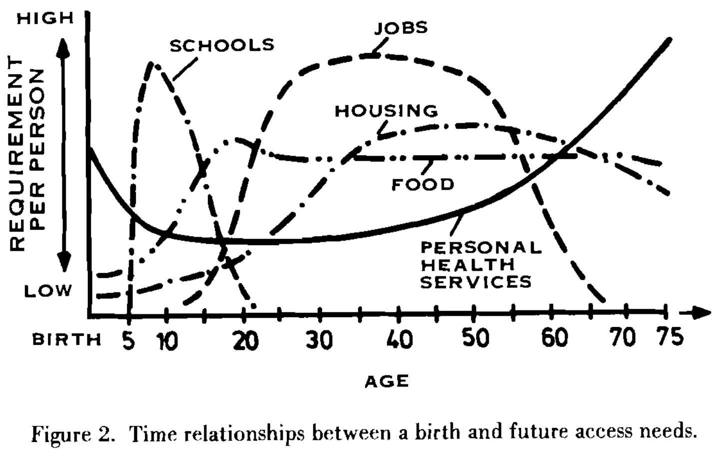

Figure 2. Time relationships between a birth and future access needs.

Source: Rogers (1977)

Thus, one approach that suggests itself is a study of individuals' (or households') life cycles. Such an approach should be of interest also to Andrei Rogers and his associates, in their work on migration. Another worthwhile focus would be on the daily cycle to which households are subjected. Through a study of the ways in which homes, work-places, and other "stations"--such as shopping centers and service facilities--in the individual's daily cycle are organized, one could obtain a better understanding than we now have of the individual's place-use and time-use, of the individual's "space-time trajectories". Problems of interaction and interdependence can then be seen as problems of synchronization of many individuals' time schedules, as problems of spatial coordination, and as problems of dimensioning of the capacities of transportation networks and other urban facilities, as discussed in the latter part of Professor Funck's paper.

2. A remarkable change in the trend of population growth has been occurring in the last few years in several countries, among them the United States. In a major departure from the past, "the trend of population growth in the United States has turned toward rural and small town areas" since 1970 (Beale 1976). Are these recent shifts in population, away from metropolitan areas and toward nonmetropolitan areas, the beginning of a major new wave of population movements to be witnessed in one country after another in the coming years? Or is it an isolated, episodic phenomenon? We do not know, but some of the facts now emerging are intriguing. In the cited study by Beale, it is found that during the period 1970-1974 the most rapid growth (14.5 percent over the four-year period) occurred in those nonmetropolitan ounties (360 out of a total of 3097 US counties) that have attracted retired people. Beale mentions such characteristics of these counties as access to water (whether lake, reservoir, or ocean), access to scenery, or to a favorable climate. Now, such migration among the elderly has attractive and interesting features from the point of view of mathematical modeling. As Professor Paelinck puts it in a different context: are the phenomena analytically reproducible?

Among these interesting analytical features are the following. First, there is the obvious labor market implication that, as an elderly couple migrates to a new area, they add to the demand for labor through their demands for goods and services, but they do not add to the supply of labor. Hence, to a larger extent than other migrants they generate new employment opportunities. Second, the composition of their consumption expenditures differs from that of other migrant categories. It is suggested that an attempt be made to comprehend, and "analytically reproduce", some of these features and their effects.

3. The third, and last, research problem concerns the relationship between regional development and industrial structure. I have been unable to find any systematic, comparative studies of how the industrial structure in a region changes as it develops. By industrial structure I here mean the composition of the

resource allocation (labor and capital) among such categories as agriculture (or perhaps better, food production and processing), manufacturing industries, energy-producing industries, service-producing sectors (with governmental services separated). Nor have I been able to find systematic, cross-sectional studies that compare the industrial structure of different regions and across countries.

What "universal" features can be sifted out from such temporal and spatial comparisons? My view is that the Swedish studies I have quoted in this brief paper, are in this sense "too loose", because they have not accounted for any "structural" relations among the industries. On the other hand, I find studies of the input-output analysis format to be "too rigid" in the same sense.

I have raised this problem here, because it seems to me that meaningful IRD studies would require some form of empirical background about these matters. Maybe some of you can help us with suggestions.

REFERENCES

Artle, R., and C. Averous (1977), The Telephone System as a Public Good: Static and Dynamic Aspects, *The Bell Journal of Economics and Management Science*, Spring.

Beale, C. (1976), A Further Look at Nonmetropolitan Population Growth Since 1970, *American Journal of Agricultural Economics*, 58, 5.

Granholm, A., and O. Ohlsson (1975), A Note on Distribution Analysis in a Linear Programming Model, *Regional Science and Urban Economics*, 5, 483-491.

Hansen, N. (1974), *Public Policy and Regional Economic Development, The Experience of Nine Western Countries*, Ballinger, Cambridge, Mass.

Hagerstrand, T. (1973), The Impact of Transport on the Quality of Life, paper given at the European Conference of Ministers of Transport, Athens.

Hagerstrand, T. (1974), in *Ortsbundna Levnadsvillkor (Place-Constrained Conditions of Living)*, SOU, Stockholm.

Ohlsson, O. (1976), *Assessing Swedish Regional Policy*, Swedish Ministry of Labor, Stockholm.

Ohlsson, O., and A. Granholm (1972), *Regionalekomiska Modeller*, SOU, Stockholm.

Ohlsson, O., and A. Granholm (1974), *Regionala prognosa i planneringens tjänst*, Part III, SOU, Stockholm.

Rogers, A. (1977), *Migration, Urbanization, Resources, and Development*, RR-77-14, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Stöhr, W.W., and F. Tödtling (1976), *Spatial Equity--Some Anti-Theses to Current Regional Development Doctrine*, IIR, Vienna.

PRESENTATIONS BY REPRESENTATIVES OF IIASA'S AREAS THAT COOPERATE WITH IRD

Potential Interactions Between IRD and the Human Settlements and Services Area

Andrei Rogers

My principal job this morning is to describe to you the Area of Human Settlements and Services within IIASA and its responsibilities, and then to elaborate on the potential collaborations that this Area could have with integrated regional development studies. The responsibility of the four Areas within IIASA are perhaps seen somewhat differently by each individual Area leader, but the mission that I see for our Area includes, first, the recruitment of a core of experts for IIASA's programs--the cross-disciplinary program that you saw in Roger Levien's matrix. Experts like to do research as well as to contribute to on-going programs, however, so to get them here we also have to allow them the freedom to carry out some of their own research and expand the state-of-the-art in their particular discipline. At the same time, through their interaction with other disciplines within the Institute, these scholars may succeed in integrating several disciplinary approaches into a multidisciplinary synthesis that can be disseminated among the National Member Organizations (NMOs). Finally, the Areas have served historically as seed-beds for potential future programs in that certain activities within Areas that seem to be "do-able" and ripe for promotion to program status have been elevated to such status before, e.g. the Food and Agriculture Program which formerly was an activity in the Resources and Environment Area.

The principal focus of research within the Human Settlements and Services Area is on people: how many are there, where are they, what are their service needs and resource demands, and what is their impact on the environment?

Areas at IIASA are long-term research departments. Programs, on the other hand, are problem-oriented projects with a finite lifetime, normally of five years. They finish a product during that period, which is disseminated to the NMOs. Although Areas do not change in principle, their research Tasks do. Within our Area, we have divided one current Task into three categories, defined in terms of the temporal perspective of the decisionmaker.

Certain problems that decisionmakers are concerned with have a rather short time perspective, say a year. The decisionmaker knows that he cannot change the system within such a short time span, but what he can do is to manipulate particular variables and adopt certain policies in order to raise the efficiency and the equity of the system. Traffic control, for example is one such problem. If you have a traffic problem, your perspective may extend over the next few months: in order to make this system run more efficiently, one-way streets may be introduced or an automated computer traffic control may be put into operation. Emergency service system planning is another example.

At the opposite extreme to these short-term problems of *management* are long-term problems of *development*. Here the time perspective is a long-range one and the mechanisms of implementation are *plans*. In such instances the system can be changed through the process of modernization; consequently decisionmakers adopt a long-run time perspective.

Between the above two classes of problems, we have the problems of *investment*, the time perspective of which is three to five years, and *programs* are the principal vehicles of their implementation--e.g. a new link in the transportation system can be built or a new hospital. We can change the system a bit but not as drastically as in the development perspective.

Within this overall delimitation of management, investment, and development problems, I should like to mention here the following Area Tasks:

- Our work on management-type problems in transportation has been completed. It was carried out by Horst Strobel, and it is now being written up as one of the IIASA State-of-the-Art Series to be published by John Wiley. Its focus is on computerized methods of traffic control.

- We are exploring the possibility of initiating a new activity that would focus on the use of computers in urban management by local governments. Some preliminary work has already been carried out here, largely by Kenneth Kraemer of the University of California at Irvine. He has written a paper on this Task.

Whereas these two Tasks deal with management-type problems, the following sets of Tasks can be looked on as dealing with human resources and service problems:

- The Modeling Health Care Task, formerly the Biomedical Project is a continuing activity (led by Evgenii Shigan) which may be expanded to include other, what we might call, "human capital/human resource" type of research projects, such as manpower and education planning.

- We are continuing two research Tasks that focus on human settlement systems. They are the Human Settlement Systems Task (led by Niles Hansen), and the Migration and Settlement Task (led by Frans Willekens). Both are reaching the stage of completion. To take their place we have initiated a new research Task: the Population, Resources, and Growth Study. Whereas our earlier work dealing with settlement problems has focused on developed countries, specifically the 17 NMOs, the new Task will focus primarily on developing countries in order to generate the scenarios that describe the developmental processes of modernization.

What I should like to do next is take these last two Tasks and describe them to you in greater detail so that we can then move on to see how they might contribute to the activities of this Task Force Meeting.

Activities in the Modeling Health Care Systems Task fall into five subtasks. First, the research on population forecasting models has generated projections disaggregated by age and sex. These are linked to a morbidity model which is age-sex specific. The combination of these sets of models generates a *demand* for health care. The *supply* of health care, as measured by hospital beds and number of doctors, for example, then needs to be matched with the demand, assuming a particular system of treatment. These supplies require resources, and the allocation of resources among alternative uses in an important focus of the simulation model that the scholars in the Modeling Health Care Systems Task are now developing. Finally, the relationships of the health care system to, and its interactions with, other external, systems, are a focus of research.

The second of the four Tasks within our Area, the Human Settlement Systems Task, is concerned with data collection and regionalization studies for as many of the NMO nations as can be obtained. These data are currently being collected within IIASA for the German-speaking countries, and at the University of Reading, UK, for the English- and French-speaking countries. Collaboration with scholars in Hungary, Poland, and the GDR, should provide us with data from those countries. Some data have been collected already and are being subjected to shift-share analyses. Finally, as the data accumulates, we may carry out studies dealing with the problems of using functional regions as against administrative regions--e.g. border regions.

The third Task, Migration and Settlement, sounds very much like the Human Settlement Systems Task if one were to judge by the title. Its content, however, is somewhat different. The focus is more on methodological aspects, and the Task derives impetus from the fact that several of us have been working on the methodology of spatial population analysis for some time before coming to IIASA and we would now like to disseminate that methodology. The first of the four subtasks in this research study is concerned with the dynamics of spatial populations, i.e. the mathematical "laws of motion" of fertility, mortality, and migration, and the changes that these events and flows have on population stocks in various regions. In contrast to the mathematical perspective of the spatial population dynamics subtask, the demometrics subtask is the statistical-econometric modeling aspects of the same demographic components of change. The policy subtask has yet again a different methodological emphasis. Unlike the mathematical descriptive approach of dynamics and the econometric approach of demometrics, the policy research is adopting the optimization approach of control theorists in mathematics, engineering, and economics. What we are trying to do here is to see whether IIASA, which has such an interdisciplinary group of control theorists, would not be a good place to develop a field that we might call normative demography. Finally, because we are at IIASA, we thought it would be useful to combine these three subtasks with data from the 17 NMO nations, to see what the dynamics, demometrics, and policy dimensions of migration and settlement are in these 17 countries.

The fourth and newest research activity (it started in January) is the Task entitled Population, Resources, and Growth. During its first several years, this Task will focus not on the "limits to growth" in a global perspective, but rather on a national/universal perspective of urban growth. It will examine rural to urban migration, its linkages with agricultural policy and economic development, and it will assess the demands for resources and services that both urban population growth and economic development stimulate. We plan to involve colleagues from the Resources and Environment Area, from the Food and Agriculture Program, from the Energy Program, and indeed our internal scholars in the Modeling Health Care Systems Task.

So this in a nutshell is the Human Settlements and Services Area. Now, what are the potential connections with IRD studies. Each of the four Tasks that I have described has a natural linkage with activities in IRD.

- First of all, the fourth Task, the one dealing with urban growth and development has a clear and direct connection with studies of IRD. The models we develop in this task will be applicable for the study of regional development problems.

- In the third Task we are developing demometric models that can be used to forecast migration flows and regional population totals, disaggregated by age, sex, and perhaps other things as well.

- Our Modeling Health Care Systems Task could be fruitfully included as a component of regional development, particularly as a representative example of what might be called the "human resources perspective" in regional development. The view that not capital, not land, but human resources are the principal wealth of regions would be the major theme.

- Our Human Settlement Systems Task could perhaps contribute something by way of explaining how innovations are diffused within a national system of cities and regions, and by identifying how this might have particular implications in the specific case study adopted for the IRD work.

In addition to the above four existing Tasks, we can institute new Tasks that would be of interest both to us and to IRD studies. One could be the activity of regional economic modeling. Here I am speaking of regional input-output, regional econometric models, and regional optimization models. Another new Task that could be developed would be one that dealt with forecasting the demand for social infrastructure in regional development projects, e.g. transportation.

Finally, research in manpower and education planning could offer yet another direction for potential interaction with the IRD studies.

Some Comments on Water Resources Within the Framework of IRD

Janusz Kindler

I would like to discuss some comments concerning water resources within the framework of integrated regional development (IRD) studies. As many of you are aware, there is a lot of similarity between water planners and regional planners, and water planners have a long tradition of working in cooperation with regional planners. But now we are going to discuss water resources within the framework of IRD. This topic is a little different from the water resource development planning exemplified by the river basin investigations.

The systems approach to various water resource analyses is shown systematically in Figure 1 to provide a background for the place of water within IRD. First, we are concerned with water supply, with the surface- and ground-water resources, and here we have at our disposal several more or less detailed models developed primarily by hydrologists; next we have water demand and control tasks that in many instances are of a competitive nature; lastly are the potential water management programs which may be of investment as well as noninvestment character. These three groups of different information together make the basic input data necessary for most water resource analyses. One very important thing is that we should also have some criteria for evaluation of water management programs or decision alternatives. Usually we then proceed further to build up some kind of model of a water resource system. Then there is a data processing-computational phase; here we apply a number of the tools now available to water resource planners, whether these are optimization or simulation techniques. But in most cases we are not able to cover all aspects of the problem by formalized mathematical models, and we have to use sensitivity, post-optimization, and other auxiliary analyses. All this finally allows one to identify a certain number of the best programs or best decisions. Usually we are dealing with three types of decisions: planning, design, or operational. Here, of course, we are mostly concerned with planning decisions.

However, water alone does not produce regional development; water projects should be considered only as one factor of a regional development program. Also, water alone does not produce economic development; there are many other significant forces that control regional, economic, and population growth. Thirdly, regional economic development is a very complex economic and social process; regions differ widely in the type of economic

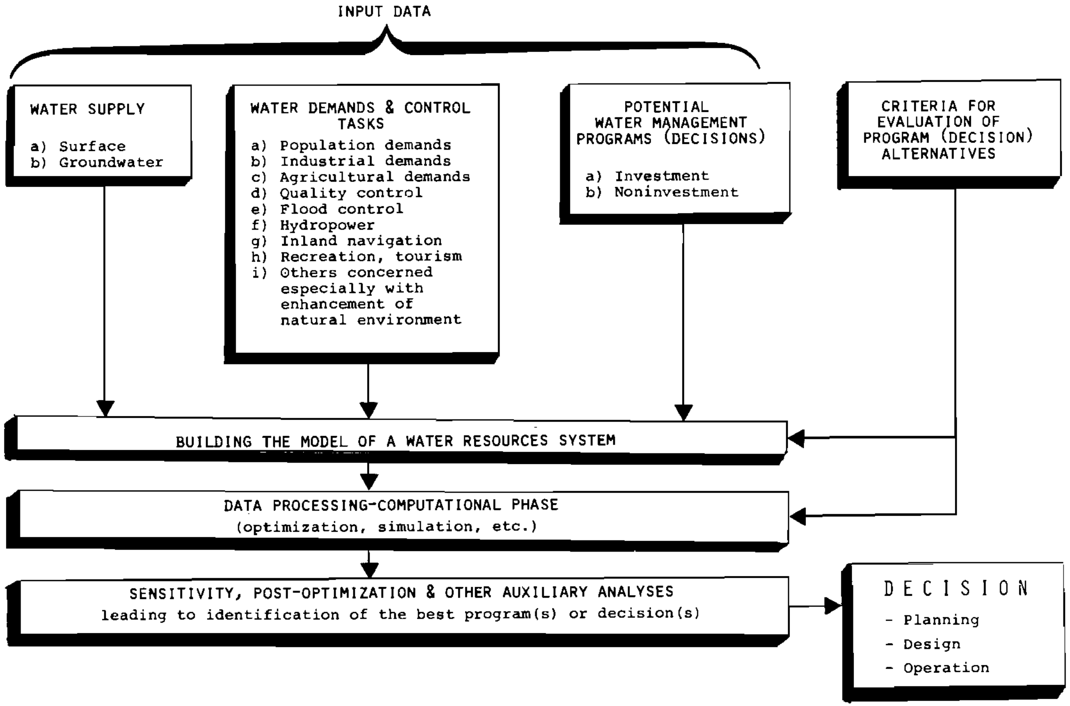

Figure 1. General scheme of water management studies.

impact that can result from the development of their water resources. Water is a mobile resource quite different from others usually considered in the regional analysis. More important, it is not only mobile, but is used and reused within the regional boundaries. The use of water, whether it be municipal, industrial, or agricultural, changes its characteristics in terms of quantity, of quality, of location, and timing of flow.

Let us remind ourselves of the major water uses we are usually dealing with: crop irrigation, municipal, industrial, waste assimilation, hydropower generation, navigation, and recreation. The particular combination of these depends on the specific region. Sometimes there is a dominating water use, but quite often we are dealing with a large number of uses simultaneously.

Water resource planners attach special importance to the relationships between land use and water use. Increasing recognition must be given to the very important impacts of land use on water resources. Shopping centers, factories, highways, strip mines, and cattle feeding operations have enormous impact on the quantity, quality, location, and timing of flows within hydrological systems. We have to remember also that in almost every use of water there is a way of accomplishing the same objective with less water but at a higher cost. And this is what we are working on now, within the framework of our water demand investigations. There is a general feeling in the water community that, in the past, must more emphasis was paid to the supply than to the demand side of the problem. So this is the reason that up to the end of this year we have been especially concerned with questions related to the forecasting of future water demands and waste discharges.

Drawing on the experience of the US National Water Commission, I would like to mention briefly some critical factors that determine water development effect on regional economic development:

- The extent of demand for water-related factors on the production of goods and services.

- The availability of low-cost substitutes for water-related factors for the production of goods and services.

- The region's competitive advantage of supplying water-related goods and services to national markets.

- The capability of the region to capitalize on development opportunities.

There is general consensus that, by now, management of existing water developments is very often much more important for improving regional growth potential than relying heavily on new water projects. Therefore a number of us concentrate on the operational aspects of water resource systems--on how decisions are actually being made, on how to operate the reservoirs most efficiently. This is also an important area of research for IRD.

Water resources need a long lead time for project planning and construction and so the time horizon employed is of special interest. Whether we see the problem in terms of the next 10 years or the next 50 years makes a fundamental difference. So a lot of thought should be given to this question before deciding on the role of water resources in any IRD studies.

There are few additional comments I would like to make about the problems that we usually encounter in water resource studies. In Figure 2, two rivers are shown schematically. The dashed line marks the boundary between the river basins. We can see that very much depends on the location of a region taken for analysis--the water problems are different depending whether the region is situated in the middle or the lowest part of the basin. Quite often regions can be located on the boundary between two river basins--e.g., the Silesia Industrial Region in Poland. Hydrologists and water resource specialists are always complaining that the economic and administrative boundaries do not correspond to the hydrological boundaries, but this is nearly always the case.

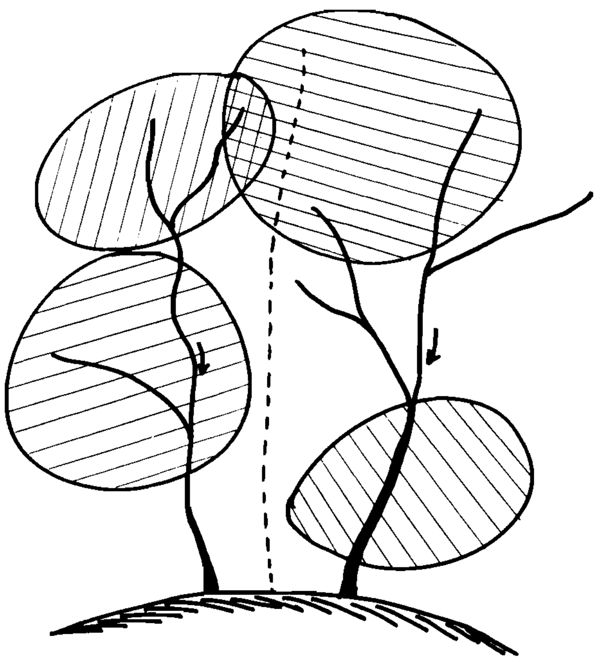

Figure 2. Region location as related to the surface water sources.

Let us assume now that we have a region as shown in Figure 3. We have the river, we have water coming from the upper part of the basin, there is a possibility of transporting some water from outside (arrow T), and finally we have ground-water intake points (marked GW). The small black points are different water users. Regardless of whether these are industrial plants, agricultural fields, or cities, we usually face a certain number of water supply alternatives. We can supply water from the reservoirs--two potential reservoirs are shown on the tributaries--there are ground-water resources, and there is the water tranfer possibility; but the real point is that we can re-use the water many times. Let us go now to more detail. On Figure 4, a small river stretch with the i-th water user is shown. The volume of water withdrawn from the river is x_i, consumptive losses are αx_i, and the remainder of $x_i(1 - \alpha)$ goes back to the river usually carrying some polluting material. One of the basic questions to be answered while initiating the IRD study is in what detail are we going to describe the i-th water user? For example, are we going to deal with single factories or will these be large industrial complexes? Are we only going to analyze water use parameters of the particular types of industry in the region or are we going to look at the problem in more detail? I think a number of such basic questions should be answered before discussing how to incorporate water in IRD studies.

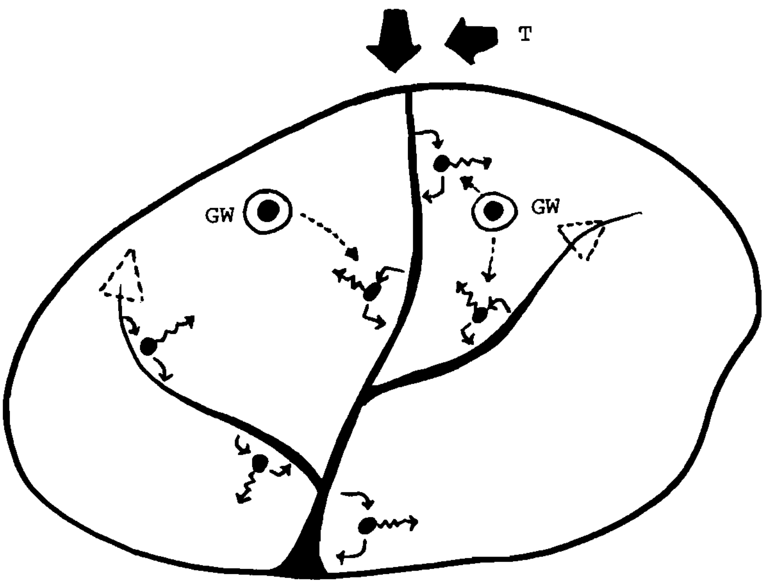

Figure 3. A hypothetical region.

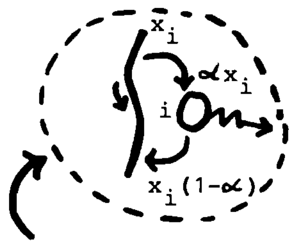

Figure 4. Scheme of a single water user.

There is another problem. The time step used in regional planning analyses is usually not less than one year. Therefore very often water resource people are requested to think about their problems also in terms of the mean annual values--e.g. mean annual flows--just to fit the overall time framework of the investigations. A small and certainly oversimplified diagram (Figure 5) indicates the danger of such an approach. In most of the cases we are dealing with the within-the-year cycle--we have excess water periods and the low water periods. If we use only the mean value of $\bar{Q}$, all particularities related to water excess periods (e.g. flood) and water shortage periods (e.g. water quality) are completely lost. This explains why in many cases we have to adopt a relatively short time step for water resource analyses.

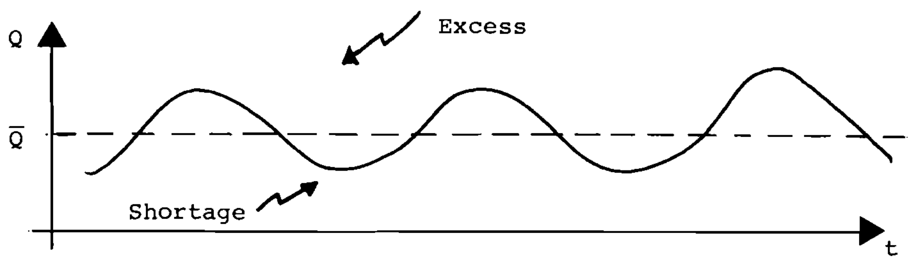

Figure 5. Water availability cycle.

I have had a number of discussions with regional planners who were very often asking us--by us I mean the water resource planners--to just tell them how much it costs to have a certain amount of water of a certain quality, available at a given time and at a given point in space: that is actually all that they needed to know! Unfortunately, there is no simple answer to this question. If you just take Figure 3, it is relatively easy to develop a water supply function (for different supply reliability levels), for the river profile marking the entrance of water to the system in question. This is especially easy if water use upstream of this profile is negligible. Such a supply function is shown schematically in Figure 6. Unfortunately, it is much more difficult to develop similar curves for the downstream water use profiles, because water availability depends to a large extent on how it was used upstream. In our present investigations at IIASA, we concentrate on various problems related to water use. The economic demand for water is what we are primarily concerned with at the present time. But the real question is water demand/water supply integration.

I have a few questions that hopefully will be answered in the discussion to follow.

We understand that what we are primarily interested in is the most rational spatial distribution of man's various undertakings and activities in a given region. We can introduce the term "location unit". Could we define in more detail the notion of a location unit? What level of aggregation will be adopted for a location unit? Water is just one of the many location factors. Are we going to develop a procedure that allows simultaneous analysis of many location factors? I am tempted to make

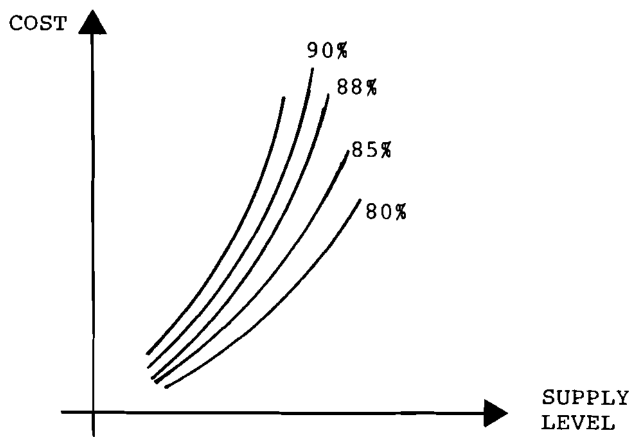

Figure 6. Water supply function.

a distinction here between computer integration of specialized models or integrated use of specialized models. Personally, I am much more in sympathy with the idea of the integrated use of specialized models. I think this is a much more realistic and practical approach.

In the field of water resource management, large numbers of different models exist, and some of them have been used in large-scale regional studies with great success. The newest ecological models have brought a new dimension to the problems of water resource development. I think the real question here is what should be selected from the many water models available to us and how to use them most efficiently in the context of the IIASA's IRD Program. There is a growing concern among model builders about what the policy implications of their modeling efforts are. How often are these models being used for decisionmaking? What is meant by decisionmaking? Therefore, before we initiate work on new models, we should probably first examine in detail the existing ones. I do hope that following the present Task Force Meeting we will have a much better understanding of the intended scope of IRD studies, and that we will try to come out with some proposals concerning water issues related to the problems of IRD.

A Multi-Factor Approach to Large-Scale Regional Development Problems (TVA and Bratsk-Ilimsk)

Andrzej Straszak

INTRODUCTION

The IIASA Management and Technology Area has systems analysis of decisionmaking processes in socioeconomic systems as its major objective. Our missions are:

- To improve the understanding of the main problems that exist at present and those that will possibly exist in the future management and technology in National Member Organization (NMO) countries;

- To prepare IIASA guidelines on important problems in management and technology for NMOs, international organizations, and other countries;

- To generalize and develop the methodologies, models, and techniques for solving planning, management, and organizational problems;

- To develop methodologies and techniques of planning, management (including management of technological change and transfer), and organizational problems for IIASA research Programs and other Areas.

There was never any doubt that regional development, especially integrated regional development (IRD) with its very complex and real socioeconomic system would be chosen as the first object of IIASA's management studies as regional problems are common to all NMO countries and are of great practical interest to them. IIASA has the necessary prerequisites for the application of systems analysis to complex socioeconomic systems, and has reasonable access to information. Regional systems may also be considered as a kind of laboratory for socioeconomic studies, especially for East-West management research, and are much more suitable than other systems for such a study.

The Cases

The first two cases that IIASA chose were the regional development programs of the Tennessee Valley Authority (TVA) in the USA and the Bratsk-Ilimsk Territorial Production Complex (BITPC) in the USSR. The methodology adopted for these retrospective case studies was designed by Professor Hans Knop who was the first leader of the Management and Technology Area.

The case studies began with international conferences held at IIASA: the TVA Conference in October 1974 and the Bratsk-Ilimsk Conference in March 1976. The former was followed by a field study by a team of IIASA scientists in June 1975 and the case study on BITPC was carried out in June 1976.

This year the Management and Technology Area is working on a third case study: the Shinkansen Project in Japan. This large-scale transportation program is not a regional program but its impact on regions is considerable.

All the development programs chosen as IIASA case studies are large-scale programs, are of regional and national importance, and have received support from their national governments. They are well known all over the world, they have helped create a new image of the country they are located in, and they have been fully or partially successful; however, the experience from them has not yet been used by other nations.

The TVA was established in 1933 as a part of President Roosevelt's New Deal policy. Its activities are concentrated in an area of about 100,000 km^2 within the Tennessee Valley watershed boundary (see Figure 1). The main goals of the project were to stop out-migration, stabilize agricultural production and modernize agriculture, prevent catastrophic floods, stimulate industrial development, develop navigation systems, and raise the general economic level.

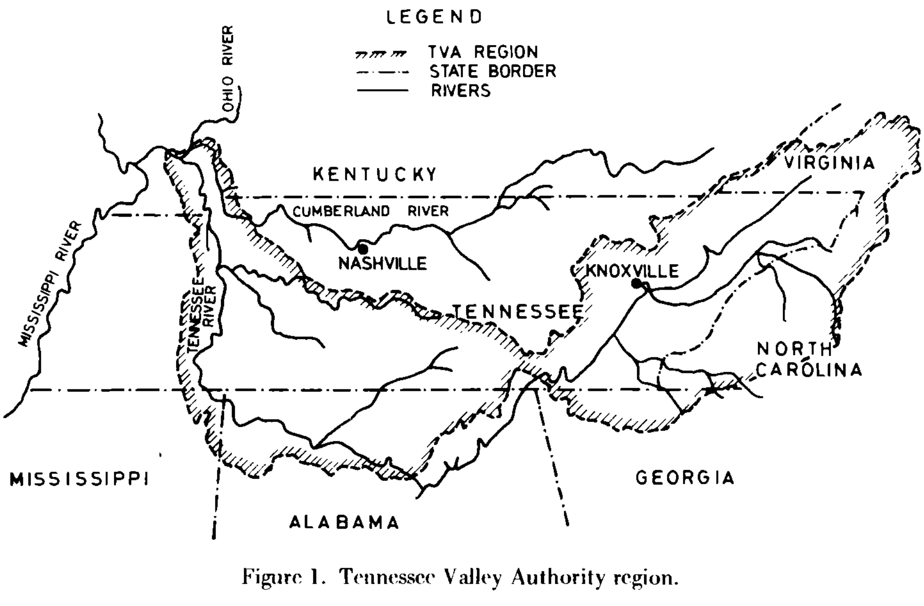

Figure 1. Tennessee Valley Authority region.

The BITPC is located in the Irkutsk region of East Siberia (Figure 2) and directly influences an area of about 100,000 km^2.

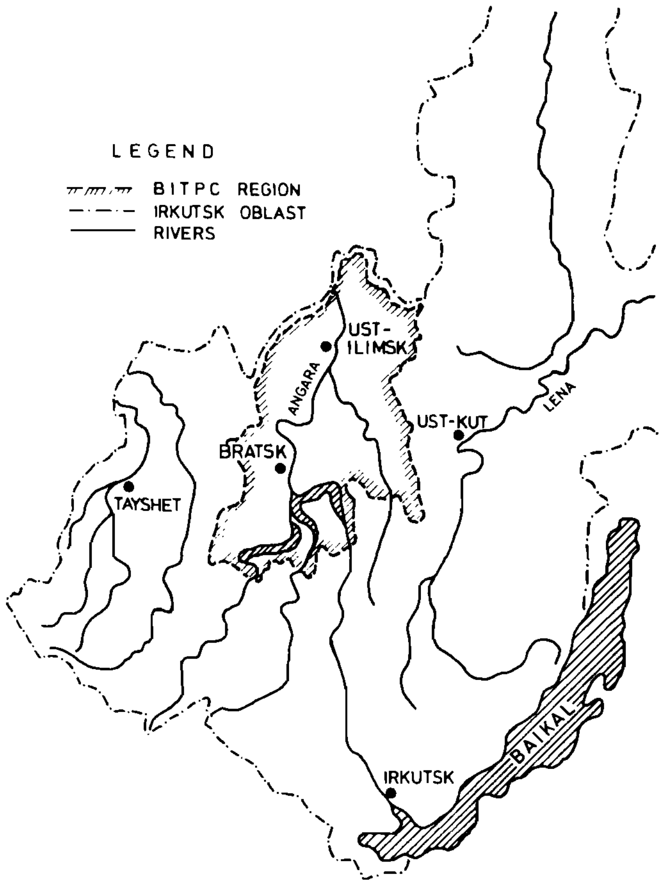

Figure 2. Bratsk-Ilimsk Territorial Production Complex.

Construction of the first dam started in 1954 as one of the major activities of the fifth Five-Year Plan of the USSR. The main goals were to develop hydroelectric power by using the inexhaustible water resources of East Siberia to provide cheap power as an incentive for exploiting and processing the rich natural resources of this region (such as iron ore and timber), to build up an efficient transport system, to develop a powerful construction industry that could also be used for development programs in adjacent territories, and to create settlements and services for industries so as to encourage in-migration despite the severe climatic conditions.

The IIASA Focus

Case studies of any complex real-life socioeconomic systems are not easy, especially by ad hoc East-West international and interdisciplinary teams, and it was therefore necessary to focus on major, dominant problems. From our experience the following are the most important (see Table 1):

Table 1.

Case Applied Fields / IIASA Focuses	Large-Scale Development Programs					
	TVA 1974/75	BITPC 1975/76	Scot-land 1976/77	Kinki 1976/78	Shin-kansen 1976/77	General-ization 1978
Goals and Strategies						
Organization and Planning						
Models and Computer Utilization						
Environmental Management						
Technology for Development						
Resources Management						

- Setting up of goals and strategies and their dynamics;
- Design and adaptation of planning and organizational procedures;
- Models and computer utilization for the development of the program;
- Environmental management;
- Technology (especially new) for development;
- Resource management.

This multifactor approach was used for the BITPC but only partially for the TVA (a complete report on the BITPC case study is being published by IIASA).

In our studies, we tried to use an analytic approach as much as possible (see Table 2). Figures 3, 4, and 5 give some idea of our study of goals and alternative dynamics. Figure 6 and Table 3 illustrate our approach to organization and planning problems. It is not necessary to elaborate just here on how models are important for IRD. During our BITPC study, we were lucky that the main driving force in model building was the Institute for Economics and Industrial Management in Novosibirsk, led by Academician Aganbegyan and that we had the opportunity to share their experience in the territorial production complex (TPC) concept.

Table 2. The Decision Analytic Approach.

Question	Formalized Answers from Case Material
Problems and Opportunities?	Hierarchy of Problems and Opportunities
Goals and Objectives?	Goal Tree
Decision Alternatives and Events?	Decision Tree
Preference Characteristics of Decisionmaking Bodies?	- Importance Weights - Utility Functions - Risk Measures - Discount Rates

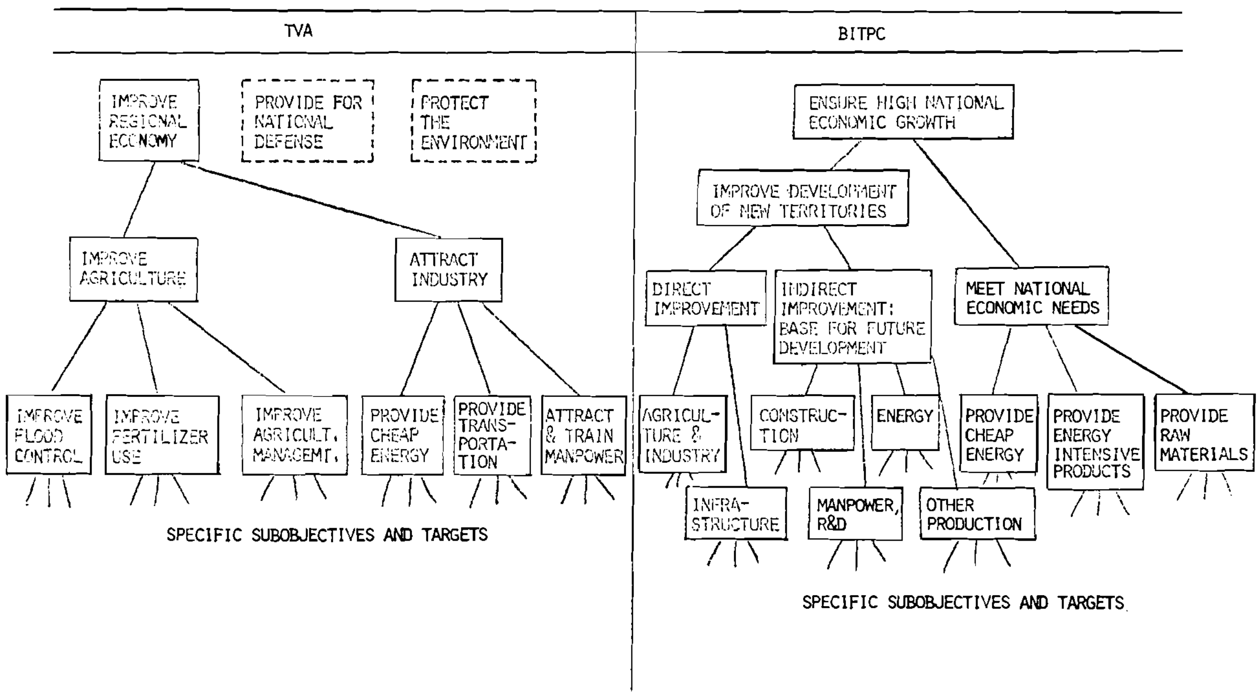

Figure 3. TVA and BITPC goals and objectives.

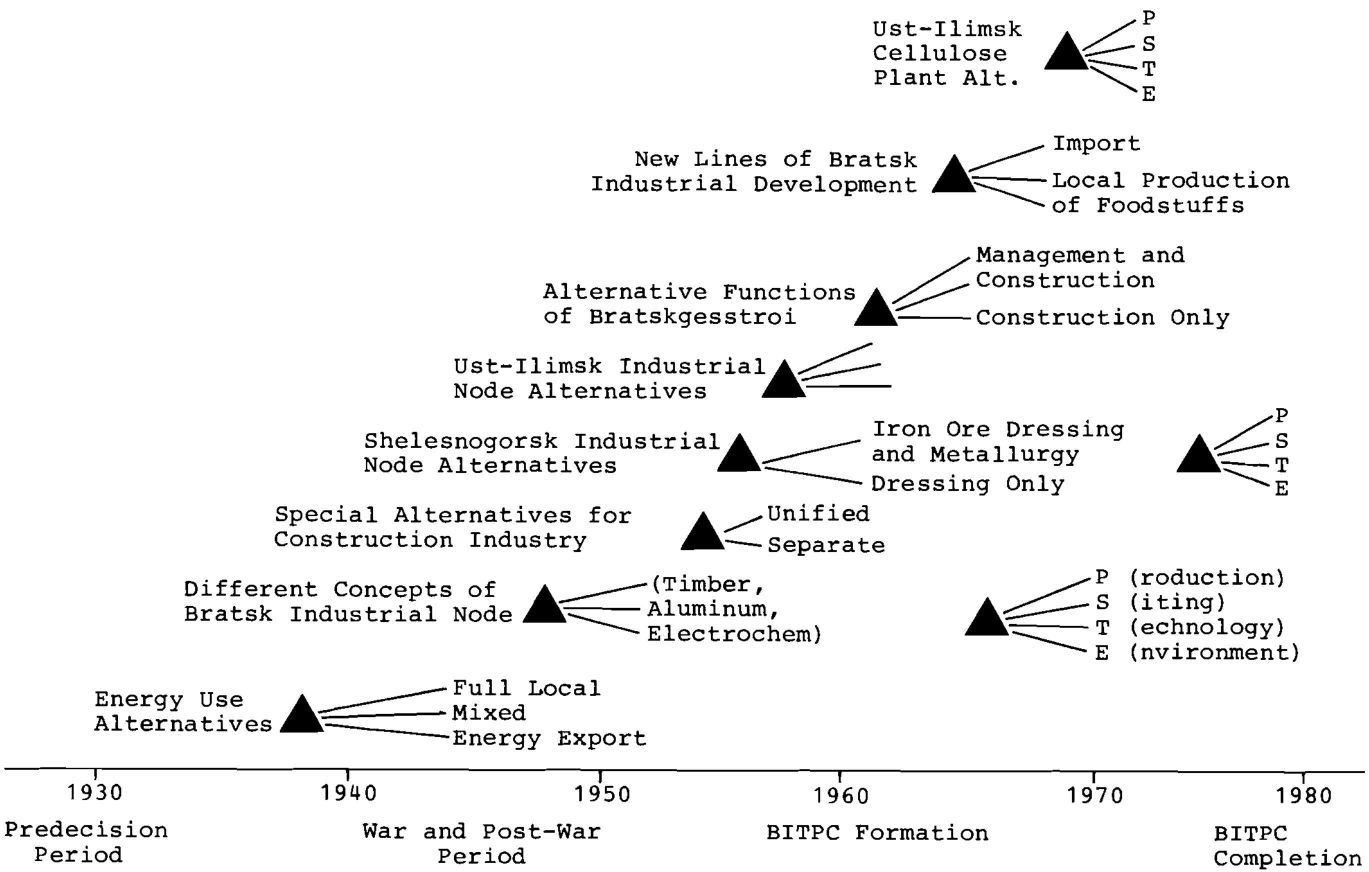

Figure 4. Production sector development alternatives.

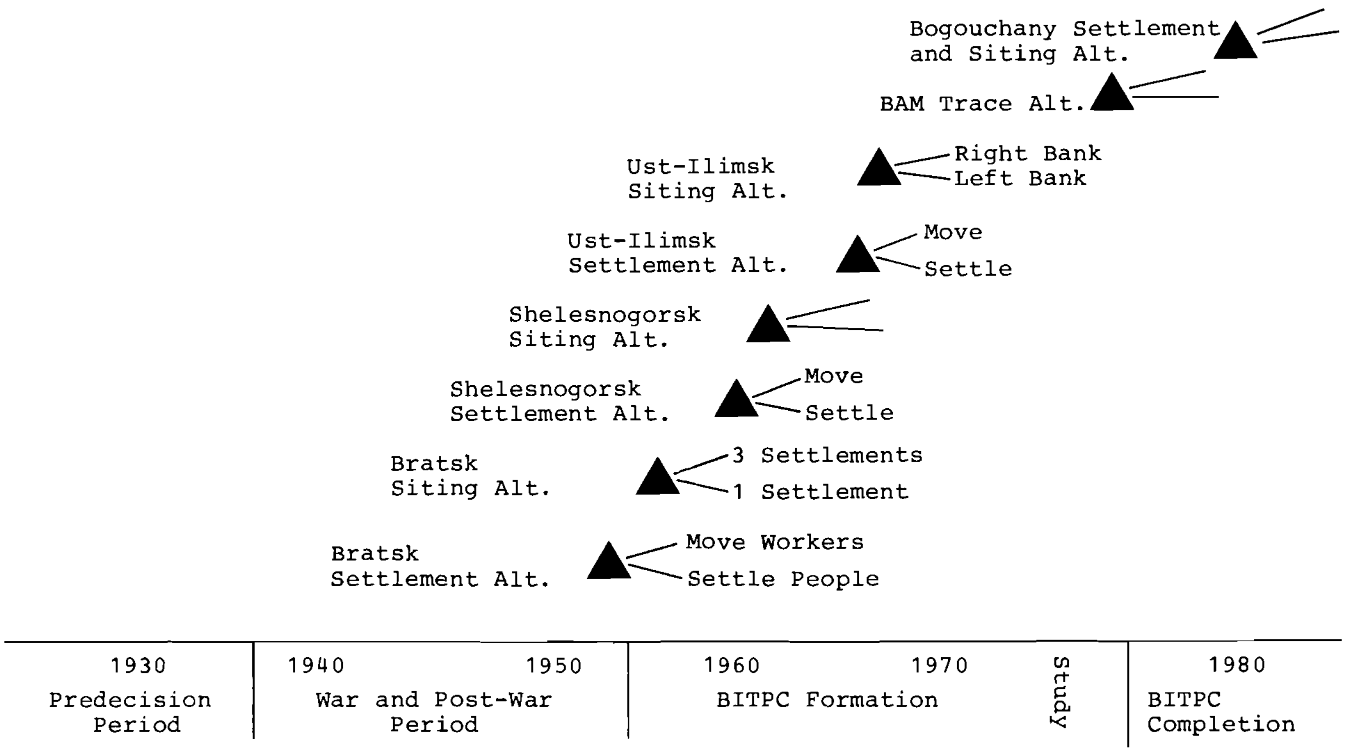

Figure 5. Infrastructure development alternative.

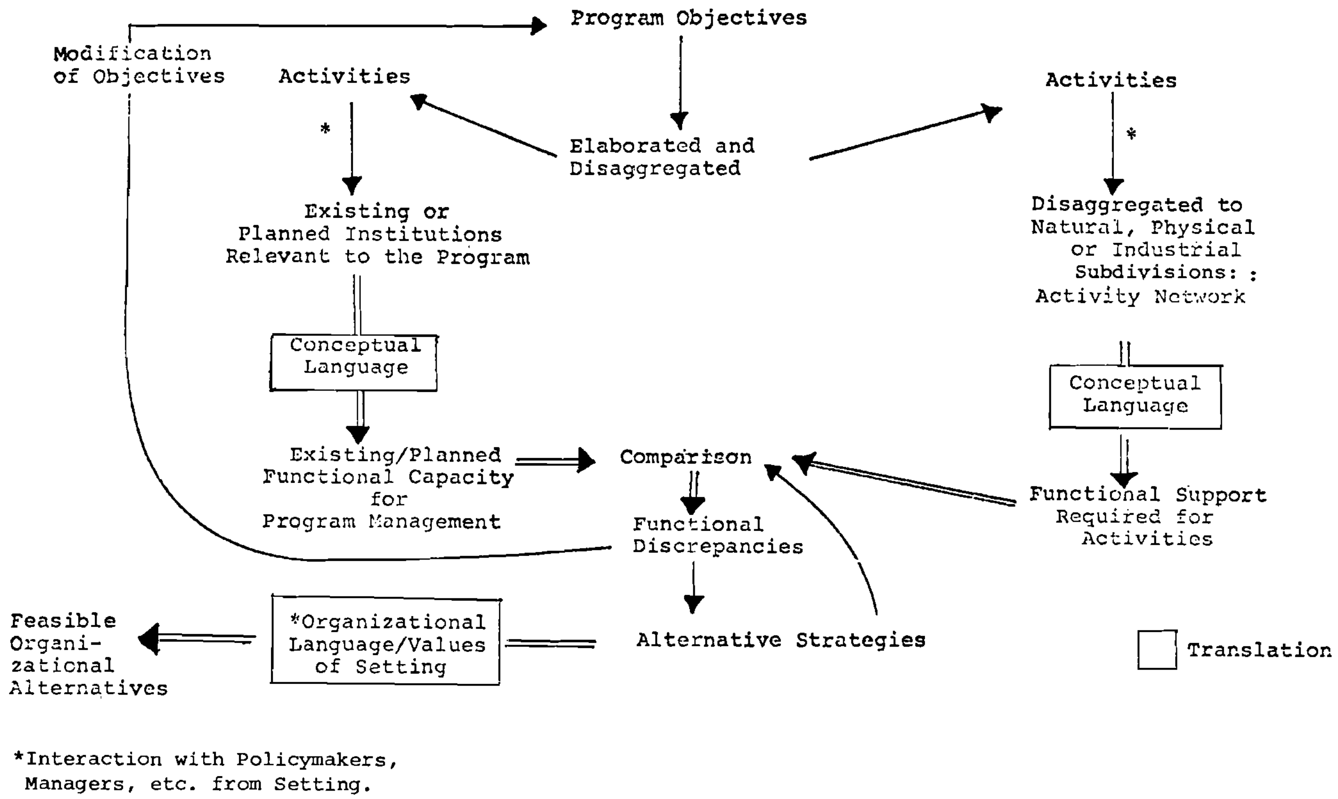

Figure 6. Stages of the analytic process.

Table 3.

Proposals \ Functions	Policy	Intelligence	Control	Coordination	Implementation
1. National Level of Planning System	Spec	Spec			
2. Local Operational Level			Syn	Syn	
3. Local Comprehensive Agency	CF	Spec CF	Spec CF Syn	Spec CF Syn	

Challenges:

Spec = Specialization

CF = Community Formation

Syn = Synchronization

The problems that could be solved through regional modeling are:

- Regionalization: which includes the breakdown of the area into socioeconomic optimal units and their clusters; problems of location;

- Coordination: which includes the linkages and the cooperation between various sectors with various and/or conflicting objectives, and sectors expressing criteria at the national level, taking local interests into account.

- Integration: which is not possible to achieve without the use of models.

Figures 7 and 8 illustrate regional normatives, balances, and models of the TVA and BITPC (italics indicate the present stage of development of the models). Figure 9 illustrates what types of models are required for an integrated development program.

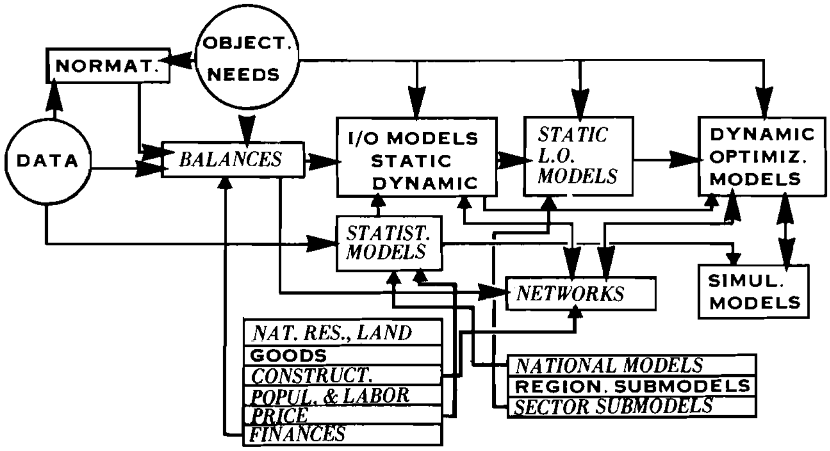

Figure 7. TVA: regional normatives, balances, and models.

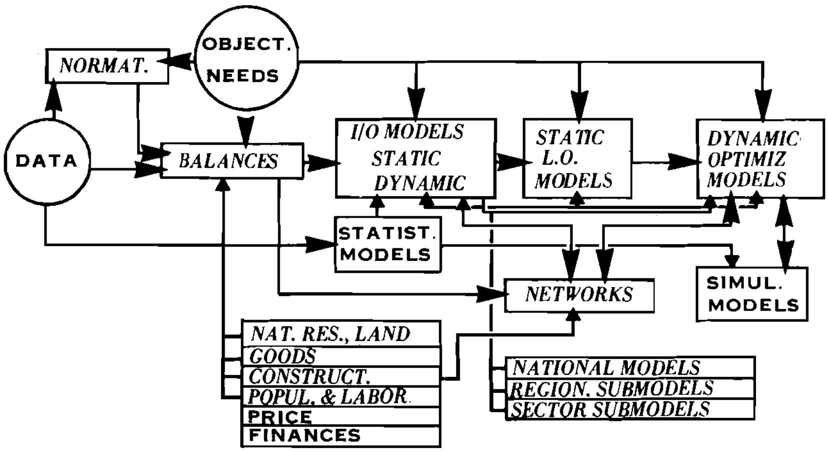

Figure 8. BITPC: regional normatives, balances, and models.

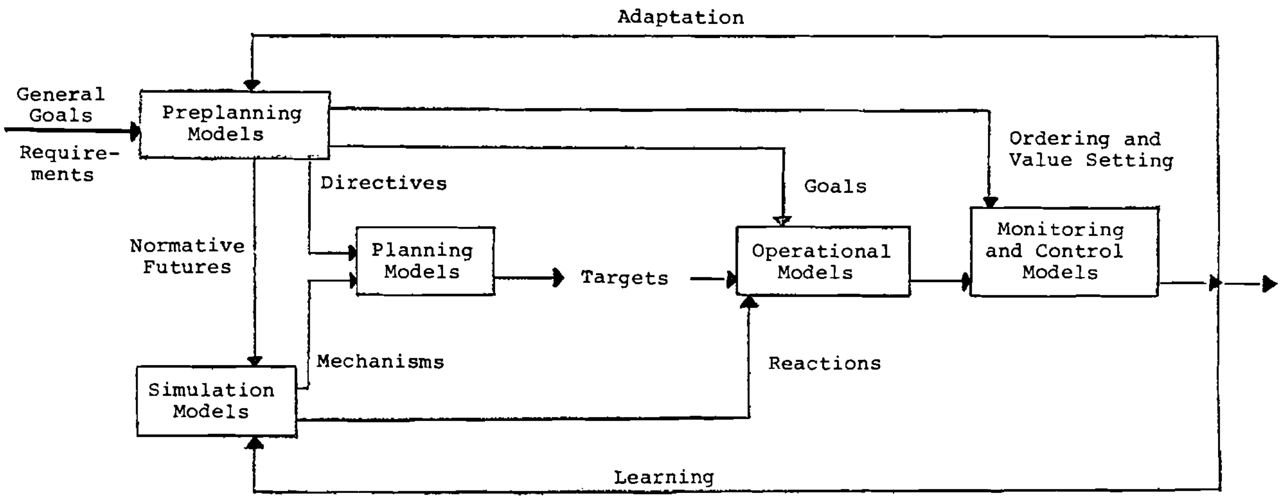

Figure 9. Types of models needed for a study of IRD.

Environmental management has come to play an increasingly important role in large-scale regional development programs. Our environmental management study includes:

- Concepts and issues of environmental management;
- Environmental and resouce potential and constraints as a function of man's activities;
- Normatives and indicators for evaluation of environmental factors;
- Pollution thresholds;
- Embedding of environmental activities in comprehensive regional planning;
- Forms and tools of environmental management;
- Institutionalization; and
- Ways and means of implementing environmental management.

In order to achieve a comprehensive and integrated approach to environmental management, research has to be carried out on modeling, planning, control, monitoring, and operations and the links between them. New technology as well as engineering institutes play a major role in large-scale regional development programs. This was true with the TVA and BITPC as well, where new and very sophisticated design and construction was made use of.

Resources are the main driving force for large-scale development programs, therefore, management of resource problems are crucial for any large-scale problems. As the most important resource of the TVA and Bratsk-Ilimsk is water, we find advanced water management systems in them.

The reasons for our retrospective case studies are not historical (see Figure 10). We are trying to generalize from experience, and case studies on complex real-life socioeconomic systems offer several advantages. They provide a large number of basic facts and data on the past and present and on the direction of development. They allow us, through conferences and field studies to communicate with politicians, managers, scientists, and the local people. Finally, such studies enable us to compare the managerial methods and tools used for solving similar problems elsewhere. IIASA is a unique institute for pursuing such studies. Its East-West character gives us the opportunity of making the experience gained from these projects universally available.

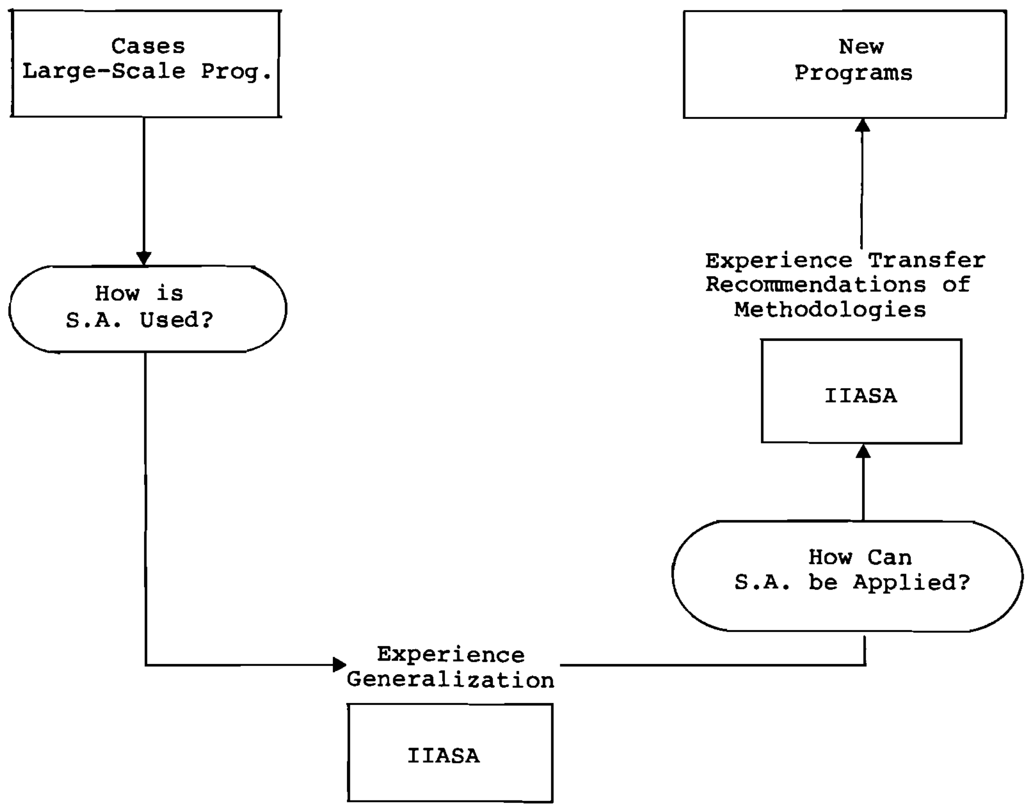
Cases
Large-Scale Prog.
How is
S.A. Used?
Experience
Generalization
IIASA
How Can
S.A. be Applied?
IIASA
Experience Transfer
Recommendations of
Methodologies
New
Programs

Figure 10.

PRESENTATIONS BY INVITED PARTICIPANTS

Proposals for the IRD Studies

Ryszard Domanski

Research into integrated regional development (IRD) should be guided by two principles: the construction of operational models and methodologies for research into IRD, and the application of IIASA models and methodologies in the research of specific regions in the NMO countries. It would be advisable to work out models and methodologies for three types of regions: newly developing regions, developed regions that are being reconstructed, and international regions.

This approach emphasizes the investigation of processes and their control. It includes construction of models of regional processes and models of interdependence between these processes. Control models should link control instruments and mechanisms with the objectives of regional development as follows:

- Mathematical models should be based on modern theories of regional processes and control. These theoretical concepts on which the models are to be based should be made before starting on any research with them.

- Theoretical concepts should reflect the essence of the regional processes. Mathematical formalization is not required at this phase. Many formal models based on unrealistic premises will thereby be eliminated.

- Attempts to construct large homogeneous regional models are not promising. The construction of an orderly set or system of models that would express various regional processes and their interdependences is more useful.

- The systematization of theoretical concepts and of their corresponding models should be based on a clear scheme in accordance with the systems analysis approach to complex problems. I propose optimal control theory as such a schema: this corresponds well with the structure of management and would give a practical character to the system of models under construction.

- When selecting and choosing theoretical concepts and models, we should give preference to those that take decisionmaking processes and the behavior of the region as their starting point. The acceptance of the decisionmaking process, the behavior of the region, and the optimal control theory as the starting point would mean that the important conditions of reality and practical usefulness of the initial research would be fulfilled.

Table 1 and Figure 1 present a model of IRD. In its simplified form, the model presents the main elements of the development process and its control. It refers to a region that is part of the country. A model of an international region will be different.

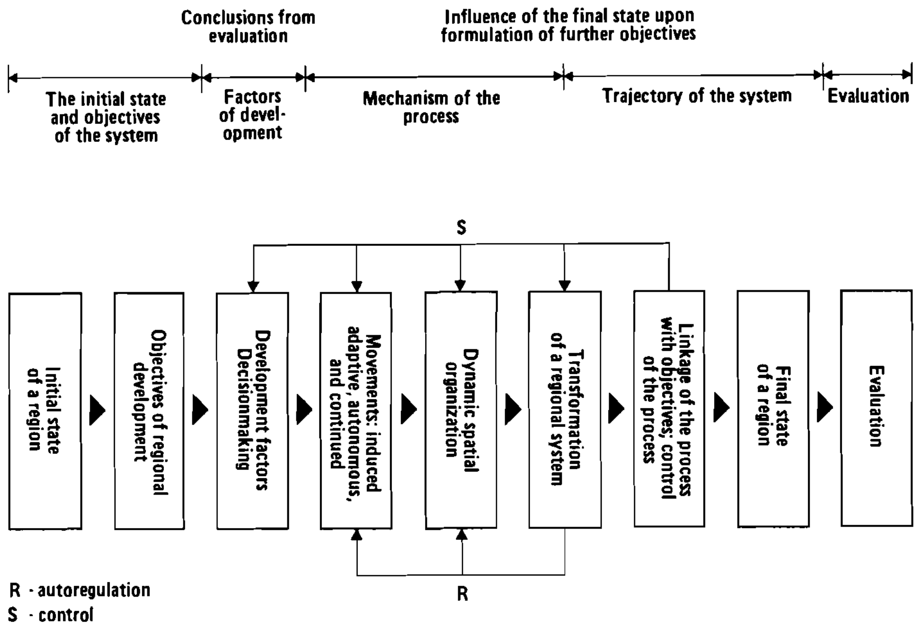

Figure 1. A model of IRD.

Table 1. A model of IRD.

I. Initial State of Region

- Population
- Settlement system
- Economy
- Environment
- Interrelations between elements of a regional system
- Connections between the region and the rest of the national system

II. Objectives of Regional Development

- Regional and national objectives; equalization of the interregional differences in people's opportunities
- Increase in the quality of life
- Improvement of the quality of the environment
- Production objectives

III. Development Factors: Decisionmaking

- Labor force
- Localization of productive investments
- Localization of social infrastructure
- Utilization of resources and environmental amenities
- Contacts, information
- Innovations
- A functioning economy, institutions

IV. Movements

- Induced movements (relocation of construction enterprises; organization of technical and social infrastructure; migration; commuting; flow of investment and production goods; flows of consumer goods; organization of new production apparatus; inflow of innovations)
- Adjustment movements
- Autonomous development
- Continuation of earlier processes

V. Dynamic Spatial Organization

- Increase in connectivity
- Limitation of complexity
- Spatial coincidence
- Agglomerations
- Unitization
- Life trails of elements of a system
- Urban and regional daily cycles
- Intervening opportunities

Table 1. (continued)

- Dependence of the organization of spatial movements on institutional structure
- Spatial barriers
- Overlapping and interrelations of various processes

VI. Transformation of a Regional Systems

- New elements of a system
- Relocation and liquidation
- Increase in scale, changes of substance and spatial reorientation of connections of a system
- Differentiated growth of elements and connections
- Changes of function without a change of place
- Structural changes
- Changes in land-use pattern
- Anisotropic deviations
- Stages of IRD

VII. Mechanisms of Processes and the Objectives of Regional Development

- Alternative objectives
- Controllability of regional systems
- Dynamic optimization
- Spatial plan: control instruments, forced directions of development

VIII. Final State of a Region

- Population
- Settlement system
- Economy
- Environment
- Interrelations between elements of a regional system
- Connections between the region and the rest of the national system

IX. Evaluation

- Degree of the implementation of objectives
- Socioeconomic effectiveness
- Conclusions for the future

Analyzing Regional Growth

Jean Paelinck

GENERAL STATEMENT OF THE PROBLEM

Looking at a map of growth rates per branch of activity for any given country, one would notice an essentially trichromatic picture: white (no growth, or negative growth), grey (moderate growth), and a few black regions (rapid growth) (Netherlands Economic Institute, 1973).

Three problems at least are raised by such a picture:

- How can it be explained?

- How is it analytically reproducible?

- How can economic policy intervene?

Entrepreneurs in quest of a region or site--we will not go into spatial aggregational details--are essentially comparing locational profiles, and it is the relative "betterness" of certain profiles that explains clustering of economic agents. The clustering itself is an informational externality that adds a snowball effect to the primary impact of outstanding profiles.

Profiles are not appreciated in a unique way, of course, and the various locational elements, if they were to be measured, can only be represented stochastically, especially the more qualitative ones. So some variation from the observed "optimal" profile down exists and accounts for at least some of the spatial dispersion of particular economic activities. This also accounts for the threshold phenomena that are implicit in the cartographic representation mentioned above. These are not unknown in economics, to mention only the field of consumption, where for the purchase of certain goods or services a minimum level of income is required.

By analogy with consumption analysis, regional growth could be presented by a tetra-n lognormal integral

$$\Delta q_{ir} = \kappa_i \int_0^{f_i(\underline{x}_r)} d\Lambda(\varphi_i - \alpha_i | \mu_i, \sigma_i^2) \qquad (1)$$

where Δq_{ir} is the growth of production of sector i in region r over a certain period, κ_i the sectoral asymptote, Λ the lognormal symbol with characteristic parameters μ(average) and σ^2(variance), α_i the threshold, f_i the locational function characteristic of sector i, $\underline{x}_r$ the relevant locational profile (vector) in region r.

Research is going on to estimate threshold effects by means of two-regime models (Paelinck, et al., 1977); the difficulty, compared with consumption analysis, is that the f_i function appearing as the upper bound of the integral is not observable like income, but has to be computed. The analysis is not without operational relevance. Indeed it has been suspected for years that what the French call "une politique de saupoudrage" is by no means an efficient way of allocating scarce resources to multiregional development.

If α_i and $f_i(\underline{x}_r)$ can be computed, one has a first idea of the *minimum gap* that has to be bridged by region ρ--that is, $\alpha_i - f_i(\underline{x}_\rho)$--in order to stimulate development in the i sector, and the same knowledge should be available for a large number of i sectors. This gap can be bridged by various economic policies, some of which are included logically in vector $\underline{x}_\rho$.

The evaluation of sector-relevant locational profiles is a necessary starting point; it is, for example, one of the important parts of the European Community (EC) project called FLEUR (Facteurs de Localisation en Europe), worked out at the Netherlands Economic Institute (Molle and van Holst, 1976).

Inverse multicriteria analysis could already be applied to such profiles, even if parts of them are expressed in qualitative terms. Comparison of the "preference zones" that allow some regions to be selected as first, second, or third best industrial or service locations, with known relative preferences, could then lead to provisional conclusions as to their possible eligibility (Mastenbroek and Paelinck, 1976).

Adequate representation of policy variables is to be looked for--by no means an easy exercise as scatter research has shown.

Finally, interregional impacts should not be neglected; the integration of this aspect can only be achieved by building a full econometric model. What the difficulties inherent to this sort of exercise are will be demonstrated in the next section.

SOME RESULTS

A provisionally more operational stochastic specification of (1) has been retained:

$$(1 - \alpha)\ \frac{q_r}{\kappa} = \frac{h_r e^{\mu_r}}{\sum} - \alpha \quad , \qquad 0 < \alpha < 1 \quad , \tag{2}$$

where $\sum$ represents the sum of the elements of the numerator of the first term of the right-hand side over all regions r analyzed. Setting

$$\alpha^* \triangleq \alpha(1 - \alpha)^{-1}\kappa \quad ,$$

one may rewrite (2) for two regions, r and s:

$$\frac{q_r + \alpha^*}{q_s + \alpha^*} = \frac{h_r e^{\mu_r}}{h_s e^{\mu_s}} \tag{3}$$

and

$$\ell n(q_r + \alpha^*) - \ell n(q_s + \alpha^*) = \ell n h_r - \ell n h_s + \mu_{rs} \quad . \tag{4}$$

Linear expansion of the left-hand side of (4) around $\alpha^* = 0$ leads to

$$\ell n q_r - \ell n q_s = -\alpha^*(q_r^{-1} - q_s^{-1}) + (\ell n h_t - \ell n h_s) + (\rho_r - \rho_s) + \mu_{rs} \quad , \tag{5}$$

where ρ_r and ρ_s are the rest of the expansions carried out.

Specification (5) introduces a double bias for α^*: first that of the linear expansion, and secondly a Markov bias, since

$$\text{cov}\left[\left(q_r^{-1} - q_s^{-1}\right)\mu_{rs}\right]$$

cannot be considered to be zero.

The simplest way to treat the term $(\rho_r - \rho_s)$ is to specify it as a constant ξ plus a stochastic term ν_{rs}:

$$\rho_r - \rho_s = \xi + \nu_{rs} \tag{6}$$

but, again,

$$\mathrm{cov}\left[\left(q_r^{-1} - q_s^{-1}\right)\nu_{rs}\right] \neq 0 \quad .$$

The solution proposed is to introduce an instrumental variable t, estimating, for increasing q_r,

$$q_r = at_r + b + e_r \quad , \qquad t = 1,2,\ldots,n_2 \quad , \tag{7}$$

where n_2 is the number of regions belonging to the "growth set", and e is the regression residuals; the exact solution of (7) can then serve to calculate the terms $(q_{rc}^{-1} - q_{sc}^{-1})$†. One observes that, in view of the a priori negative correlation of $\ell nq_r - \ell nq_s$ with $q_r^{-1} - q_s^{-1}$, parameter α^* should have a negative sign, which would be correct††.

The final specification would then be:

$$\ell nq_r - \ell nq_s \cong -\alpha^*(q_{rc}^{-1} - q_{sc}^{-1}) + (\ell nh_r - \ell nh_s) + c + \mu_{rs} \quad . \tag{8}$$

Parameters κ and α can easily be estimated as follows:

$$(1 - \hat{\alpha})^{-1}\kappa \triangleq \hat{\kappa}^* = \frac{\sum}{n_1} \sum_r \frac{q_r + \hat{\alpha}^*}{\hat{h}_r} \quad , \tag{9a}$$

$$\hat{\alpha} = \hat{\alpha}^*\hat{\kappa}^{*-1} \quad , \tag{9b}$$

$$\hat{\kappa} = \hat{\kappa}^*(1 - \hat{\alpha}) \quad . \tag{9c}$$

Equation (8) has been tested on fictitious data; an α-section (12;3456) has been made a priori, the exercise being focused on the estimation of the parameters of (8). Equation

†A two-step least-square solution had to be discarded: it would lead to multicollinearity; besides, the exogenous regressors are unknown at the start, as will be seen later on.

††One might have thought of expanding a term of type $\ell n(h_r - \alpha)e^{\mu r}$; but the term g_r^{-1} would have implied extra problems of numerical calculus, because its composition is unknown at the start.

(2.17) of Paelinck, et al. (1976) was applied to the data given in Table 1. Table 2 reproduces the accessibility data.

Table 1. The variables.

r	q	d	f
1	0	9	2
2	0	31	3
3	15	13	16
4	20	7	15
5	25	11	27
6	27	16	25

q, production levels; d, regional demand; f, a supply factor.

Table 2. Accessibilities a_{rs}.

r	1	2	3	4	5	6
1	1	1/4	1/10	1/8	1/3	1/6
2	1/4	1	1/25	1/2	1/5	1/7
3	1/10	1/15	1	1/25	1/8	1/2
4	1/8	1/2	1/25	1	1/10	1/12
5	1/3	1/5	1/8	1/10	1	1/4
6	1/6	1/7	1/2	1/12	1/4	1

With a $\log_e$ type Cobb-Douglas function for h_r, equation (3.17) of Paelinck, et al.* gives (no correction being made for

*Corrected by a buffer term to set a ceiling to the composite Paelinck, et al. accessibilities.

the bias to be discussed below):

$$\ell n q_r - \ell n q_s = B_1 \sum_\rho [1 + (e-1)]^{-1} e^{\gamma_1 a_{r\rho}} (1 + e^{\gamma_s})^{-1} (a_{r\rho} - a_{s\rho}) \ell n d_\rho$$

$$+ B_1^* \sum_\rho \ell n[1 + (e-1)a_{r\rho}] e^{\gamma_1 a_{r\rho}} (1 + e^{\gamma_1})^{-1} (a_{r\rho} - a_{s\rho}) \ell n d_\rho$$

$$+ B_2 \sum_\rho [1 + (e-1)a_{r\rho}]^{-1} e^{\gamma_2 a_{r\rho}} (1 + e)^{-1} (a_{r\rho} - a_{s\rho}) \ell n f_\rho$$

$$+ B_2^* \sum_\rho \ell n[1 + (e-1)a_{r\rho}]^{-1} e^{\gamma_2 a_{r\rho}} (1 + e)^{-1} (a_{r\rho} - a_{s\rho}) \ell n f_\rho$$

$$+ C(q_r^{-1} - q_s^{-1}) + D + \mu_{r\rho} \quad ,$$

with $B_1 = (e-1)\beta_1$, (10a)
$B_1^* = \beta_1\gamma_1$, (10b)
$B_2 = (e-1)\beta_2$, (10c)
$B_2^* = \beta_2\gamma_2$, (10d)
$C = -\alpha^*$ of Equation (8) , and (10e)
D is a constant .

The "chattering" problem of previous exercises (Lee and Markus, 1967; Paelinck, et al., 1976), which was due to the fact that the iterative process used to estimate γ_1 and γ_2 had two cumulation points instead of one convergence point, has now been solved. The introduction of the buffers

$$[1 + e^x]^{-1} \quad , \qquad x = \gamma_1, \gamma_2 \quad ,$$

as well as re-starting the iteration process at the average cumulation point has made it possible to reach convergence. It seems that the process is only locally stable, in a small neighborhood of the solution point.

The solutions obtained are given in Table 3 and from them Figure 1 could be drawn. The solution is obviously not feasible; however, the exercise being primarily concerned with the problem

Table 3. Solutions: three runs with ten iterations in the last one; $R^2 \approx 1$.

Parameters	β_1	γ_1	β_2	γ_2	α^*	α	κ	D
Values	0.050	0.425	0.040	0.420	19.829	0.119	102.376	≈ 0

of econometric estimation, and algorithms for solving the combinatorial problem being known (e.g. "back-tracking"), the point has not been stressed.

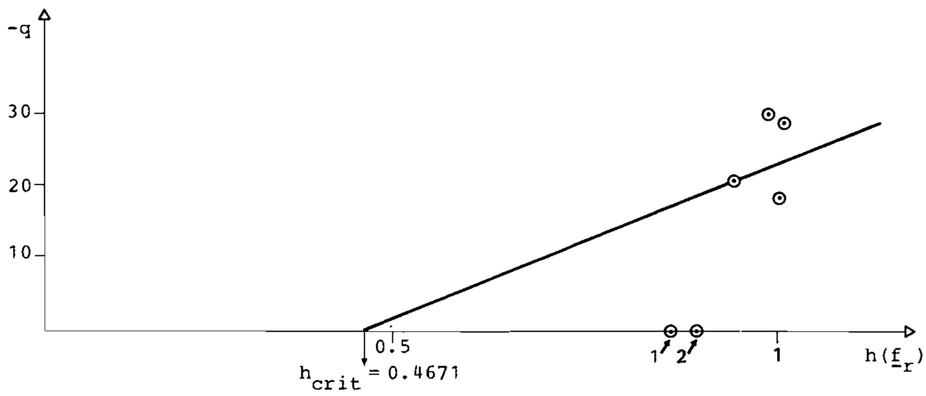

Figure 1. Graph of the solution.

CONCLUSIONS

The application presented above has two aspects. One is theoretical and concerned with the estimation of certain kinds of functions relevant to regional quantitative analysis. The other is practical and concerned with the use of models for preparing regional policy. We have stressed the necessity of constructing appropriate spatial econometric models to enable us, among other things, to measure the gaps $\hat{\alpha} - \hat{g}(\underline{x}) > 0$ that could be filled by measures of regional economic policy or physical planning. These models should be looked upon as a precious auxiliary discipline for preparing multiregional decisions.

REFERENCES

Lee, F.B., and L. Markus (1967), *Foundations of Optimal Control Theory*, Wiley, New York, p. 266.

Mastenbroek, P., and J. Paelinck (1976), Qualitative Multiple Criteria Analysis: Non-Linearities, Uncertainty, and Mixed Quantitative and Qualitative Information, *International Journal of Transport Economics*, 3, 3, 43-62.

Molle, W., and B. van Holst (1976), Factors of Location in Europe, A Progress Report, *Foundations of Empirical Economic Research*, No. 15, NEI, Rotterdam.

Netherlands Economic Institute (1973), *Mimosa, a Multiregional Multisectoral Model for Spain*, NEI, Rotterdam.

Paelinck, J., H. Smit, and Sj. Wagenaar (1976), Estimation du modèle d'attraction interrégional ouvert: une application d'économétrie spatiale, *Foundations of Empirical Economic Research*, No. 16, NEI, Rotterdam.

Paelinck, J., H. Smit, and H. Stijnen (1977), Estimation de modèles spatiaux à deux régimes, *Foundations of Empirical Economic Research*, No. 4, NEI, Rotterdam.

IRD with Special Emphasis on Environmental Components

G. Scimemi, P. Fano, and M. Lo Cascio

INTRODUCTION

With the flourishing of interest in regional phenomena in the past decades, there exists a quite extensive and select basic literature on regional development at the global or integrated level. This can be seen by the broadening attention placed on the interrelationships between regional subsystems such as human settlements (broadly defined) and the environment both in its anthropic and strictly natural components.

Notwithstanding the considerable resources deployed, it appears that there have been rather few scientifically significant applications based on the general theoretical and methodological frameworks provided by the literature to real world phenomena yet. On the other hand, a number of analytical and methodological techniques have been developed and successfully applied to specific subsystems such as water resource development and management, pollution abatement and control, rational planning of human settlements, and so on: the common characteristic of these methods being their application. This results in an accumulation of knowledge and techniques as well as a reduction in costs.

GUIDELINES FOR RESEARCH

With a general ecological, spatial, and economic theoretical framework as guideline (Isard 1971, 1974), it is possible and highly promising to attack the problems of integrated regional development (IRD) reasonably realistically by defining a general systems model capable of comprehensively incorporating relevant and well explored sectoral (subsystems) models. A similar approach could be usefully tested by "revisiting" a region where, typically, integrated planning ventures have been undertaken in various social and economic areas, yet with rather loose definitions of the overall performance and results expected as well as of objectives.

An essential part of the study consists in identifying overall (integrated) characteristics of the systems, with objectives comprehensively redefined, and with explicit decision mechanisms and behavior. Appropriate inclusion (specification of interrelationships) of environmental aspects, usually overlooked or poorly defined, would be crucial at this stage.

Simulation of actual development could then be carried out to make a formal appraisal of the results in relation to the objectives. Simulation could also be carried out in the search for more effective planning strategies, trade-offs between conflicting goals, social opportunity costs implied by given decisions, etc. The usefulness of such study would consist not only in gaining more insight into the complexities of IRD, but more significantly in laying the foundations for rational policies and efficient management.

It is strongly felt therefore that the true value of IRD research lies beyond the mere development of a general theoretical methodology. In fact, if not translated into something of general applicability and subjected to testing on real world phenomena, any theoretical or methodological construct, however innovative and sophisticated, would basically remain an abstract exercise. IRD research should be linked to a specific case study, albeit one whose problems are sufficiently general in scope to make possible the extension of techniques and approach employed to other regions and cases.

A POSSIBLE CASE STUDY

A good case study for an IRD project would be one of the so-called "Progetti Speciali" (henceforth, PS) promoted by the Cassa per il Mezzogiorno within the overall regional and economic planning effort currently being undertaken in Italy.

Since the postwar years, Italy's efforts in the development of its southern regions has attracted much attention both from scholars and governments throughout the world. The reason for such interest is above all perhaps the sheer size of the problem --approximately one half of the nation, the Mezzogiorno is a "lagging area" within a country that has experienced sustained industrial growth over the past decades--and the"originality" of many of the regional policies set forth, some of which have been adopted (and/or adapted) in various other countries.

Although the effectiveness of these policies has not fully met expectations, none the less it is of great interest to assess new governmental attitudes towards IRD as reflected in evolving legislation and action. This feed-back mechanism, while by no means perfect has brought about the practice of planning via projects of PS which, being "product-oriented", should fit actual needs of the regions in question better.

The legislation*, translated, says the PS for plans in the regions of the Mezzogiorno are of intersectoral or interregional nature. Their object is the realization of a large scale general infrastructure or the promotion of productive activities--in

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***Repubblica Italiana, Legge 6 ottobre 1971, n. 853 (Intervento Straordinario nel Mezzogiorno).*

particular, the localization of industry, the utilization and preservation of natural resources and of the environment with recourse, when called for, to initiatives of high scientific and technological content, the realization of organic complexes of public works and services in metropolitan areas and in new growth centers, and the development of economic activity in select or specific territories or productive sections.

The Cassa per il Mezzogiorno PS 14, "Utilizzazione inter-esettoriale delle acque degli schemi idrici nelle Regioni Puglia e Basilicata" (Intersectoral use of the Puglia and Basilicata Region's water systems) could provide an extremely interesting case study for the IRD project*.

The region has the following characteristics:

- It is a so-called backward area;
- It has experienced intensive, publically sustained, industrialization in recent years, although unequally distributed;
- It has many coastal areas whose value for alternative uses (recreation, tourism, etc.) is threatened by industrial complexes;
- It possesses many historic and artistic assets that will deteriorate in the absence of adequate anti-pollution measures;
- It has a water scarcity problem;
- It is subject to general environmental deterioration due to pollution by industry, agriculture, and human settlements.

Various plans, more or less organically conceived, have been launched at various levels of government and in different sectors under the PS in a coordinated attempt to foster economic and social growth.

Water scarcity is among the more severely limiting factors of development of the Puglia and Basilicata administrative regions, that together form the object of the PS. The broad planning objectives for these regions call for an accelerated growth rate in manifacturing industries, vast irrigation programs for agriculture, an urban policy of greater efficiency in the provision of public and private goods and services, development of the tourist industry, and the protection of the natural and historic environment.

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*The authors wish to thank Prof. Petriccione of the Cassa per il Mezzogiorno and President of the Cassa Systems Analysis Commission for his willingness to afford his personal as well as the Cassa's collaboration should IIASA decide to study PS 14.

Although the PS itself is keyed to the development of a water planning model capable of satisfying the multiple demands (in space and time) of the various sectors of the regional economy until the year 2001, a model of more general scope is required if effectiveness is to be measured in terms of overall development objectives.

In the next section, a possible approach is given that distinguishes between a general sythetic systems model and meaningful decomposable subsystem models.

A POSSIBLE METHODLOGICAL APPROACH

Figure 1 shows a simplified model of IRD analysis, including management aspects of environmental resources. The basic loop of this system defines the criteria for public action that reflect value judgments related to the utility of resources in relation to their various uses--subject to constraints of previously enacted safeguard and development policies.

The three main blocks depict:

- State conditions and transformation of broadly defined physical resources (anthropic and natural components);

- Resource uses (life supporting, productive, and waste disposal capacity);

- Development and safeguard actions (normative, administrative, and those related to specific programs).

The interdependences within and between the three blocks identify the system's "behavioral" model, i.e. the constraints it is subjected to. The optimal state of the system is reached by maximization of a social preference function, whose arguments may be given by either:

- The availability and spatial distribution of the physical resources, measured in terms of residential, productive, infrastructural, and environmental stocks; or

- The conflicting uses of resources.

A similar approach, appropriately developed, would constitute a general theoretical framework, especially useful for interpreting the role of various phenomena and respective measurements or indicators, and for making explicit underlying value judgments and simplyfing assumptions inherent in any social calculus.

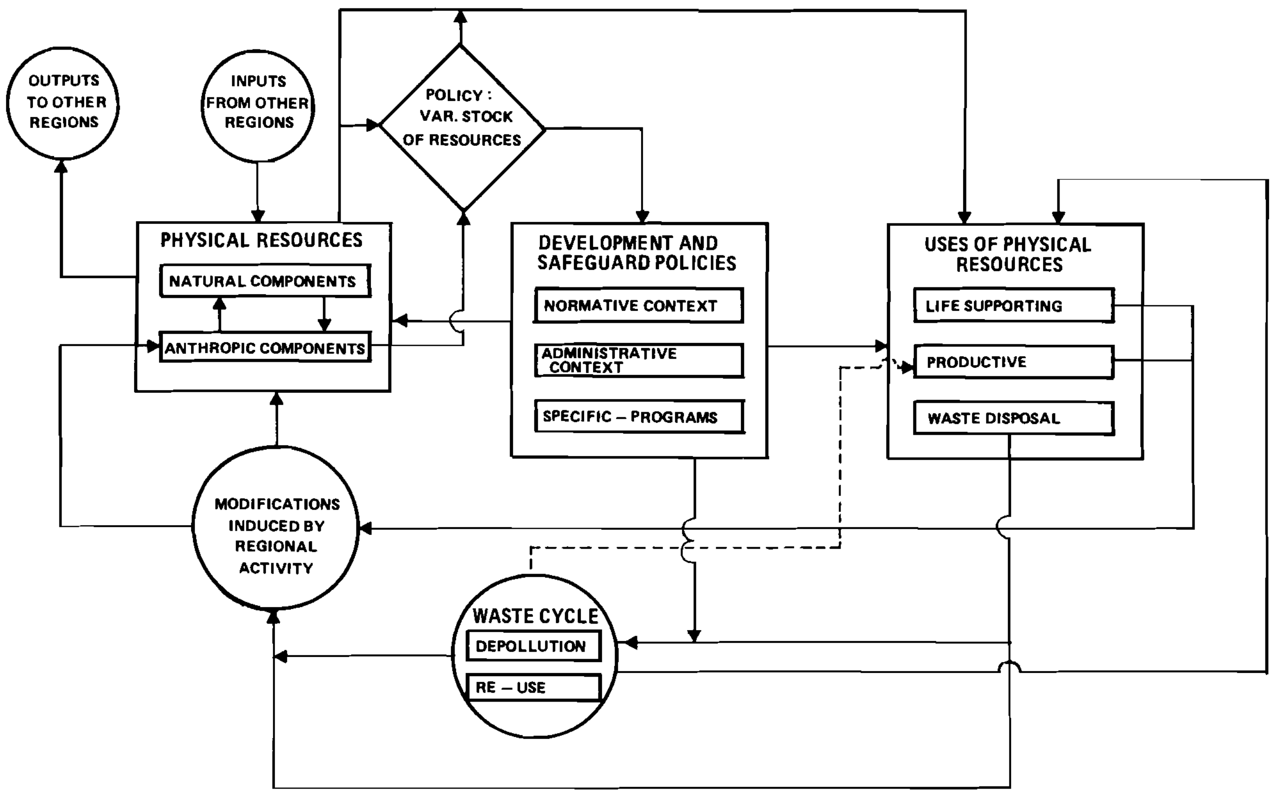

Figure 1. Simplified model of IRD analysis.

This general approach does not appear viable as a basis for building a simulation or optimization model that includes all relevant interrelations because of the inherent complexities:

- There is insufficient knowledge concerning some of the phenomena necessary to satisfactorily complete such a model.

- It is very often difficult to distinguish between weak and strong linkages (e.g. sensitivity analysis is not reliable).

- Such models are expensive and time consuming to build.

- It is difficult, or would otherwise contain too much redundancy to account for all the variables involved in a meaningful objective function.

- There may be improper and only partial use of well-defined specific submodels.

The general methodology suggested now, while inspired by the previous approach, attempts to simplify procedures in order to tackle IRD on a more operational basis.

We propose to decompose the regional system into subsystems, each of which is directed to explore economic efficiency implications connected with the management of a single or a group of resources*. Overall system optimization could be achieved by specifying a social preference function, whose arguments and constraints derive from an aggregation of solution values of the various subsystem runs.

The characteristics of the subsystem models are:

- Specification of a set of constraints for each resource, or group of resources, in order to satisfy the resource-uses-development and safeguard policies loop;

- Parametric variation of constraints in order to identify the frontier of "efficient" solutions, within fixed limits in order to take in account major linkage effects between subsystems.

The overall system model operates on aggregate variables of significance to public decisionmakers (area income and its spatial distribution, level and geography of social capital,

*Note that these subsystems are not subareas of the region, nor single sector models (e.g. production model, transportation model, waste model, etc.).

spatial distribution of production, costs related to development and safeguard policies for the environment and resources, etc.). Its purpose is essentially:

- To generate alternative base configurations for the subsystems;
- To specify the parametric variability of constraints in subsystems;
- To evaluate socioeconomic profitability of different system configurations and correlate the effectiveness of alternative policies.

The subsystems identified are:

- Human and activity system;
- Weather resources development and management system;
- Natural environment and pollution abatement and control system.

While it does not appear viable, at this stage, to consider a fourth subsystem "development and conservation of energy" separately, such a possibility would nevertheless be worth exploring due to the new impacts that energy systems will assume on regional organization in the future.

REFERENCES

Isard, W. et al. (1971), *Ecologic-Economic Analysis for Regional Development*, Free Press, New York.

Isard W. (1974), *Activity-Industrial Complex Analysis for Environmental Management*, Paper No. 33, The Regional Science Association, Philadelphia.

An Outline of a Dynamical Systems Approach to IRD

Walter Isard

I will outline some of the ideas we are developing on the relevance of a multilevel dynamical systems approach to integrated regional development (IRD). A full treatment of these ideas will be forthcoming in several long papers which I will be presenting at the 1977 Krakow meetings of the Regional Science Association and at meetings of the World University of the World Academy of Art and Science. (See also Liossatos, 1976; Isard and Liossatos, 1977; and Mesarovic, et al., 1970.) I begin

I begin with a simple example. Imagine a "two-region" system S transforming over a relevant time period $[t_0, t_1]$ a time pattern of inputs E into a time pattern of stocks of social wealth (goods, health, and other tangibles and nontangibles), let us say *social stock*. We let $y \equiv (y_1, y_2)$ represent the time pattern of social stock for regions 1 and 2 in order. This time pattern of social stocks is the resultant of the behavior and interaction of the following subsystems: a decisionmaking unit D_1 for region 1, and decisionmaking unit D_2 for region 2, a coordinator, and an overall process P summarizing production activities (see Figure 1). The overall process P is an input-output relation over the period t_0. The time patterns of inputs are m_1 and m_2. The time pattern of outputs are y_1 and y_2. The overall process is the resultant of the two subprocesses 1 and 2, and their time pattern of interactions (couplings) represented by the box designated "Field". Subprocesses 1 and 2 represent production activities in regions 1 and 2, respectively, and are controlled by the respective decisionmaking units that select m_1 and m_2. In effect, the decisionmaking unit D_1 together with subprocess 1 represents region 1;* and the decisionmaking unit D_2 together with subprocess 2, region 2.

Let us analyze the system S where we take E as fixed (hence ignored in the discussion that follows) and where the subprocesses 1 and 2 are given respectively by the linear differential equations:

$$\dot{y}_1(t) = m_1(t) + u_1(t) - a_{11}y_1(t); \quad y_1(t_0) = y_{10} \quad , \qquad (1)$$

*As indicated by Figure 1, region 1 as a system transforms inputs γ and u_1 into output y_1.

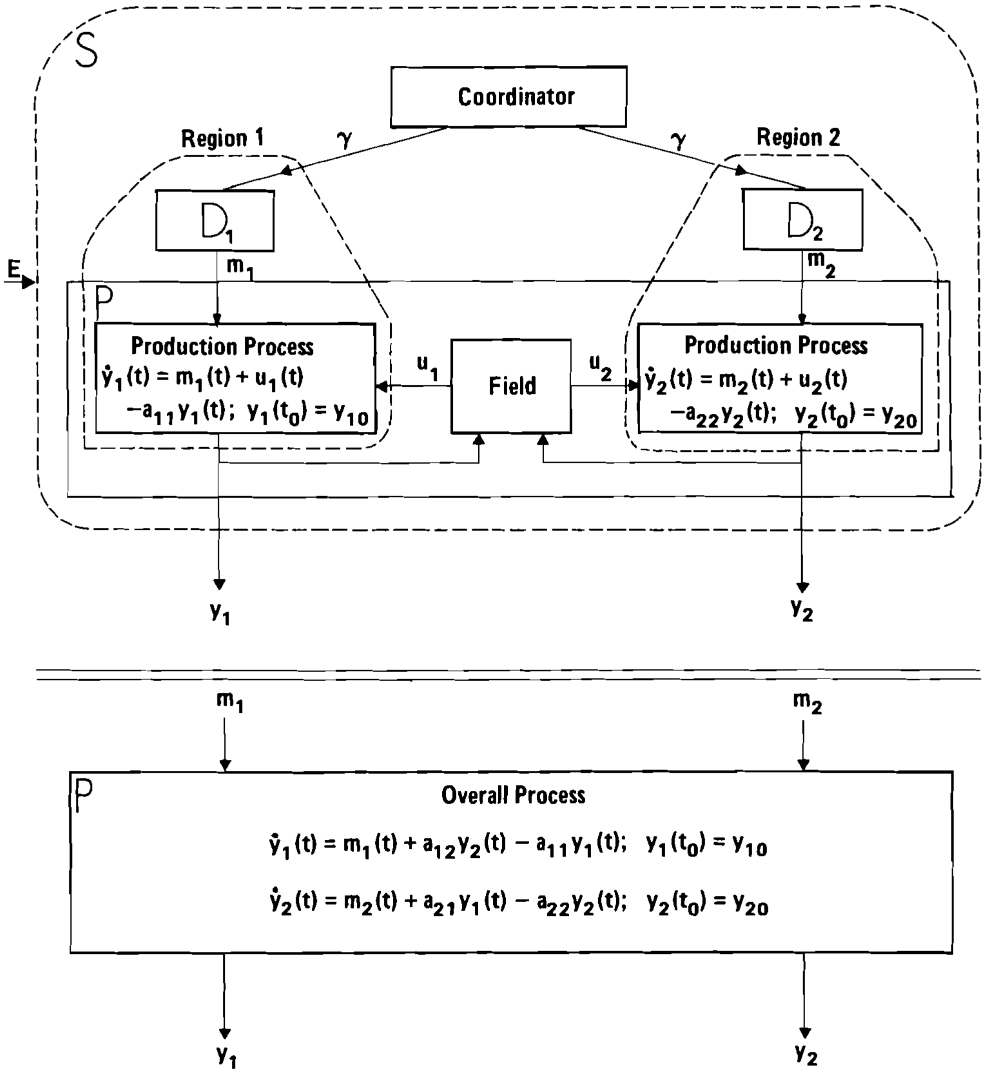

Figure 1. Command flows and production in a system.

$$\dot{y}_2(t) = m_2(t) + u_2(t) - a_{22}y_2(t); \quad y_2(t_0) = y_{20} \quad , \tag{2}$$

for $t_0 \leq t \leq t_1$. In Equations (1) and (2), $y_i(t)$, $i = 1,2$, may be viewed as social stock at time t. $\dot{y}_i(t)$ is its time rate of change. $m_i(t)$ is a control variable of the ith decisionmaking unit summarizing the decision regarding the use of labor (or any other type of resource or energy, etc.) per unit of time. When multiplied by appropriate dimensional constants, it can also be expressed in units of social stock and thus can measure the amount of social stock produced from labor per unit of time. $u_i(t)$ is the net effect per unit of time of interaction upon production, where this net effect may be either positive (say from flow of information, or sense of rivalry) or negative (say from pollution diffusion). Finally, the social stock depreciates over time, the constant a_{ii} measuring the rate of depreciation of the stock; the amount of depreciation per unit of time being $a_{ii}y_i(t)$. y_{i0} is the initial value of the stock at t_0 which is taken as already specified. Thus Equations (1) and (2) state for each time t that the rate of change in social stock of region i is equal to the sum of the output from the application of labor (energy) per unit of time *plus* the output (either positive or negative) from the presence of interaction summarized by the interface input *minus* the amount of depreciation (a loss) per unit of time.

Observe that for each selection of a control input $t \to m_i(t)$, and an interface input $t \to u_i(t)$, each equation uniquely determines a time pattern of social stock. Symbolically, Equations (1) and (2) are equivalent, respectively, to:

$$y_1 = P_1(m_1, u_1) \tag{3}$$

and

$$y_2 = P_2(m_2, u_2) \quad , \tag{4}$$

where the symbols m_i, u_i, and y_i represent time patterns. The couplings between the two subprocesses are

$$u_1 = a_{12}y_2 \equiv h_1(m,y) \quad , \tag{5}$$

$$u_2 = a_{21}y_1 \equiv h_2(m,y) \quad . \tag{6}$$

The coefficient a_{12} is the coupling coefficient, taken to be constant, indicating the effect of a unit of social stock of region 2 on the rate of output of social stock of region 1. The coefficient a_{21} is the parallel coefficient. Using Equations (5) and (6) to eliminate u_1 and u_2, we see that the overall process is:

$$y_1 = m_1 + a_{12}y_2 - a_{11}y_1 \quad ; \quad y_1(t_0) = y_{10} \quad ,$$

$$y_2 = m_2 + a_{21}y_1 - a_{22}y_2 \quad ; \quad y_2(t_0) = y_{20} \quad . \tag{7}$$

For any given control input, namely $t \rightarrow m(t) \equiv (m_1(t), m_2(t))$, Equation (7) uniquely determines a time pattern of social stocks, $t \rightarrow y(t) \equiv (y_1(t), y_2(t))$. That is, Equation (7) determines y as a function P of m, that is:

$$y = P(m) \quad , \tag{8}$$

where m and y represent time patterns.

In addition to a production process there is a decisionmaking unit within each region i. This decisionmaking unit optimizes a payoff (objective) function G_i by manipulating m_i subject to the constraint of its production process. However, we assume that each decisionmaking unit operates as a part of an organization in which there exists a superior coordinating-type of decisionmaking unit. Thus the payoff function of the ith region depends not only on the variables m_i, u_i, and y_i pertaining to its respective subprocess but also on the parameters imposed by the coordinator, $t \rightarrow \gamma(t) = (\gamma_1(t), \gamma_2(t))$--which we now designate coordination input. For example, let the payoff function, or more generally the performance functions, be:

$$G_1(m_1,u_1,y_1,\gamma) = \int_{t_0}^{t_1} \Big[m_1^2 + (a_{12}r_2 - u_1)^2 + q_1(r_1 - y_1)^2 + \gamma_1 u_1 + \gamma_2 a_{21} y_1 \Big] dt \quad , \tag{9}$$

$$G_2(m_2,u_2,y_2,\gamma) = \int_{t_0}^{t_1} \Big[m_2^2 + (a_{21}r_1 - u_2)^2 + q_2(r_2 - y_2)^2 + \gamma_2 u_2 + \gamma_1 a_{12} y_2 \Big] dt \quad , \tag{10}$$

where time arguments are omitted from the integrands, and where r_1 and r_2 are large positive constants playing the role of targets (desired level of stocks). G_1 and G_2 are essentially cost functionals. In Equation (9) the integrand is total cost per unit of time. The third term, $\bar{q}_1(r_1-y_1(t))^2$, is a cost associated with not reaching the target r_1 where $|r_1-y_1(t)|$ is the deviation from that target and $\bar{q}_1$ is a cost coefficient. When $y_1(t) = r_1$, this cost is zero; but when the target is set high enough, such can be achieved only with application of control inputs (labor). Such inputs, however, are costly, their cost taken to be $m_1^2(t)$, the first term in the integrand; its coefficient is set at unity so that $\bar{q}_1$ indicates the relative importance of these two costs. The second term in the integrand is a cost that the decisionmaker of region 1 associates with each level of u_1. In this particular situation we assume that he knows $a_{12}r_2$ and knows that there is a cost, $a_{12}r_2^2$, inflicted upon region 1 that is reducible by the extent of interaction u_1; so the decisionmaker of region 1 desires that $u_1 = a_{12}r_2$. Observe that if the interaction is the correct one, namely, $u_1 = a_{12}y_2$, then this term becomes a cost inflicted on region 1 because region 2 does not reach its target. The fourth and fifth terms are subsidies and penalties imposed by the coordinator which, as discussed before, are regulations of the system. We interpret the payoff definition of region 2 given by equation (10) similarly.

We posit that the overall two region system functions like an organized whole--the optimal performance of the whole is of importance and concern to all its parts. To convey this idea we posit that there be an overall performance function G that depends in general on the time patterns of control inputs and social stocks. For example

$$G(m,y) = \int_{t_0}^{t_1} \left[m_1^2 + m_2^2 + q_1(r_1-y_1)^2 + q_2(r_2-y_2)^2\right]dt \quad , \tag{11}$$

where time arguments are omitted from the integrand. Here q_1 and q_2 are positive constants, indicating the relative importance of the cost terms. The first two are, as before, costs from control inputs (labor), and the last two terms costs from failing to reach targets. If we take

$$\bar{q}_1 \equiv q_1-a_{21}^2 > 0 \quad ,$$

$$\bar{q}_2 \equiv q_2-a_{12}^2 > 0 \quad , \tag{12}$$

then we can show that if the interactions are the correct ones, as given by Equations (5) and (6), then the overall system cost functional is the sum of the cost functionals of the two units. That is

$$G(m,y) = G_1(m_1,a_{12}y_2,y_1,\gamma) + G_2(m_2,a_{21}y_1,y_2,\gamma) \quad . \tag{13}$$

As before, there are four decision problems. The overall decision problem is to minimize $G(m,y)$ subject to Equations (7) or (8). The decision problem of region $i(i = 1,2)$ is to minimize $G_i(m_i,u_i,y_i,\gamma)$ subject to Equations (1) or (2); or (3) or (4). The coordinator's decision problem is to select γ so that when all regions respond by choosing their optimal decisions, system optimization automatically results.

Consider the optimal control problem of region 1. We construct the current Hamiltonian

$$H_1 = (m_1)^2 + (a_{12}r_2-u_1)^2 + \bar{q}_1(r_1-y_1)^2$$

$$+\gamma_1u_1 - \gamma_2a_{21}y_1 - p_1(m_1+u_1-a_{11}y_1) \quad . \tag{14}$$

The minimum principle with reference to m_1 (the controllable input) and u_1 (as if it were a controllable input), that is $\partial H_1/\partial m_1 = 0$ and $\partial H_1/\partial u_1 = 0$, yield:

$$p_1 = 2m_1 \tag{15}$$

$$p_1 = -2(a_{12}r_2-u_1) + \gamma_1 \tag{16}$$

assuming interior optima. By the nature of the costate variable in the Hamiltonian, $p_1(t)$ is the imputed price of an additional unit of $y_1(t)$ (capital stock at time t). As discussed elsewhere, $p_1(t)$ is a value that region 1 assigns to a unit of additional output (capital stock) at time t because of anticipated cost savings over the time period $[t,t_1]$. This being the case, Equation (15) states that at each time t the control (labor) input should be increased up to the point where its marginal cost (disutility), $2m_1(t)$, equals the imputed price $p_1(t)$ of $y_1(t)$. Equation (16) in similar manner states that at each time t, the desired level of interaction (interface input), namely $u_1(t)$, should be increased to the point where its marginal net cost $[-2(a_{12}r_2-u_1(t) + \gamma_1(t)]$ falls to the level of the imputed price $p_1(t)$. Note that by elimination of p_1. Equations (15) and (16) yield

$$2m_1 = -2(a_{12}r_2-u_1) + \gamma_1 \quad , \tag{17}$$

which in one sense represents a substitution principle between two inputs, namely that their marginal costs must be the same--a basic allocation principle of optimization.

In addition to Equations (15) and (16), minimization of the cost functional of region 1 requires that Hamilton's equation be satisfied, namely:*

$$\dot{p}_1 = \partial H_1/\partial y_1 \quad , \tag{18}$$

which yields

$$\dot{p}_1 = -2\overline{q}_1(r_1-y_1) - \gamma_2 a_{21} + a_{11}p_1 \quad ; \quad p_1(t_1) = 0 \quad . \tag{19}$$

The meaning of Equation (19) is best seen if we multiply both sides by dt and integrate to obtain:

$$p_1(t) = \int_t^{t_1} [2\overline{q}_1(r_1-y_1(t') + \gamma_2(t')a_{21} - a_{11}p_1(t')]dt' \quad . \tag{20}$$

In the integrand, the first term is the reduction in cost by being one unit closer to the target r_1, a marginal cost saving. The second term, $\gamma_2(t')a_{21}$, is the subsidy or penalty applied by the coordinator to a unit of $y_1(t')$. The third term, $-a_{11}p_1$, represents a depreciation cost. Altogether the three terms in the integrand yield current net returns, or net cost savings, or net gains per unit of capital stock at t'. Hence Equation (20) states that the level $y_1(t)$ of capital at t should be increased up to point where the cumulative sum of its current net returns over the time period $[t,t_1]$ comes to equal its imputed price at time t--an investment-type principle.

For region 2, we obtain the parallel optimality conditions:

$$p_2 = 2m_2 \quad , \tag{21}$$

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*Note that, given our definition of the costate variable in Equation (12), the usual form of Hamilton's equation involving a negative sign on the right-hand side becomes Equation (18).

$$p_2 = -2(a_{21}r_1-u_2) + \gamma_2 \quad , \tag{22}$$

$$\dot{p}_2 = -2\bar{q}_2(r_2-y_2) - \gamma_1 a_{12} + a_{22}p_2 \quad ; \qquad p_2(t_1) = 0 \quad . \tag{23}$$

By solving Equations (11), (15), (16), and (19) we obtain for region 1 the optimal inputs $\{m_1,u_1\}$ as functions of the coordination input γ. To show this dependence we write these inputs as m_1^γ,u_1^γ which collectively is the optimal decision of region 1 for given γ. Similarly region 2 obtains m_2^γ,u_2^γ for given γ.

Next consider the coordinator's problem. His strategy is based on the fact that each subunit can select m_i^γ and u_i^γ but can apply only m_i^γ. The interactions that result from the application of m_1^γ and m_2^γ are in general different from those desired. From Equations (15), (16), and (18), the actual interactions (interface inputs) are:

$$\bar{u}_1^\gamma = a_{12}y_2^\gamma = a_{12}P_2(m_1^\gamma,m_2^\gamma) \quad , \tag{24}$$

$$\bar{u}_2^\gamma = a_{21}y_1^\gamma = a_{21}P_1(m_1^\gamma,m_2^\gamma) \quad . \tag{25}$$

Hence the coordinator's job is to choose γ so that

$$\bar{u}_i^\gamma = u_i^\gamma \quad , \qquad i = 1,2 \quad . \tag{26}$$

As shown in Mesarovic, et al. (pp. 178-181), a solution $\hat{\gamma}$ to Equation (26) exists and in addition

$$\hat{m}_i = m_i^{\hat{\gamma}} \quad , \tag{27}$$

where $\hat{m} = (\hat{m}_1,\hat{m}_2)$ is the optimal control for the overall problem. We let $\hat{y} = (\hat{y}_1,\hat{y}_2)$ be the resulting capital stocks obtainable from Equation (18). Relation (27) states that the optimal controls selected by the units are the optimal controls for the system. It necessarily follows from Equation (17) that

$$\hat{y}_i = 2\hat{m}_1 - 2a_{12}(\hat{y}_2 - r_2) \quad ; \qquad i = 1,2 \quad . \tag{28}$$

The previous development can be generalized to n processes and to nonlinear differential equations. Instead of Equations (11) and (12) we now have

$$\dot{y}_i(t) = f_i(y_i(t), m_i(t), u_i(t)) \quad ; \quad y_i(t_0) = y_{i0} \quad , \tag{29}$$

for $i = 1,\ldots,n$ for $t_0 \leq t \leq t_1$, which relates the time rate of change of output of any subprocess i to all outputs and inputs (control and interface) of all processes. The couplings between subprocesses are specified by a set of relations of the form

$$u_i = h_i(m,y) \equiv (y_1,\ldots,y_{i-1},y_{i+1},\ldots,y_n;$$

$$m_1,\ldots,m_{i-1},m_{i+1},\ldots,m_n) \quad , \quad i = 1,\ldots,n \quad . \tag{30}$$

Here we make a specific choice of interface input by taking the interface input to be all the outputs and control inputs except those of i. Note that other possible forms of h_i can be selected.

The system I have depicted is exceedingly simple. It does not recognize stochastic elements or the playing of games by regions when dealing with the coordinator. All I wish to do here is to point out one fruitful direction for research on IRD--but a direction which may need twenty years of cultivation before useful applications are possible.

REFERENCES

Liossatos, P. (1976), Dynamics and Coordination of Spatially Interacting Processes, paper presented to the Northeast Regional Science Association, Cornell University, Ithaca, New York, April 23-25, 1976.

Isard, W. and P. Liossatos (1977), *Optimal Space-Time Development*, in preparation.

Mesarovic, M.D., D. Macko, and Y. Takahara (1970), *Theory of Hierarchical Multilevel Systems*, Academic Press, New York.

Some Views on IRD

F.E. Ian Hamilton

INTRODUCTION: LIMITS TO THE CHANGES ACHIEVED BY REGIONAL DEVELOPMENT

Interest in the question of regional development has grown very rapidly in recent years both among sections of the scientific community and among policy decisionmakers throughout the world. The volume of work published has multiplied at an accelerating rate during the past decade. In part this reflects the rise of regional science and spatial economics which have had powerful influences upon the theoretical, methodological, and analytical approaches to regional development issues. In part it expresses the increasing involvement of international research and assistance agencies, especially United Nations agencies, in the practical aspects of development trends and programs.

However, if one examines the world's myriad of nations--from the most virgin to the most highly developed--it is striking how relatively few cases of dramatic new regional development have occurred in the last two decades and how prominent is the continuity of existing or former spatial patterns of development. This is not to deny that regional change has been significant and has modified existing patterns: rather they have not been radical.

Two points require emphasis:

- Successes in new regional development have been far less spectacular than the enormous volume of research would appear to indicate. This is underlined by the substantial amount of writing concerned with the problems experienced in, and limitations on, regional development.

- The degree of intraregional and interregional spatial structural changes has varied widely from country to country and indeed from region to region and is closely associated with the degree of national development and the rate of national innovation.

There are many explanations for the apparent divergence between research effort and practical achievement. I will now outline the most significant.

Knowledge of the Processes of Regional Development

This has been inadequate during the past twenty years. Nevertheless that understanding has greatly improved from the rather crude level of "investment implantations" to a sophisticated appreciation of reality that demands proper assessment of:

- Both the social and the economic factors involved in development, and
- The complex spatial and structural patterns of the transmission and leakage of the impacts of innovation within national and international socioeconomic systems.

Time Lags and Communication Barriers

There are time lags and communication barriers involved in translating quite dynamic and often complex scientific insights, ideas, models, and strategies into simplified frameworks understandable enough for policymakers to turn into practical action, and these have to be considered.

Priority given to National Development

The priority concern among most of the governments of the countries of the world has been for *national* development. This has simultaneously

- Absorbed expertise and resources to the detriment of the quality of designs and implementation of regional development, and
- centralized decisionmaking power to the detriment of local and provincial initiatives, interests, and influence in economic enterprise and in local provision.

This priority concern has had paradoxical impacts in practical development terms:

- Regional development has often been viewed by policymakers in rather simplistic terms, with "investment implantation" in production being seen as the solution to regional problems since the region is treated--erroneously--as a fairly closed system from which little "leakage" of growth effects occurs.
- Such implantation on a large scale to meet national needs first and regional development requirements second has increased the "interregionalization" of the regional economy within the nation, i.e. interregional linkages and hence "leakages" increase, and this is frequently accompanied by

varying degrees of "internationalization" of regional dependence, i.e. a growth in the "external" or "overseas" influence on the regional economy. These trends are complex and carry potential socioeconomic and political-sovereignty conflicts in some cases while in others they may be mutually supporting.

Dynamism of the Environment

The very dynamism of the "environment" within which decisions, plans, and actions for regional development have to be put into effect has had an impact. There have been changes in technology which:

- Increase the scale and concentration of production and services, their specialization, management, inputs, infrastructure requirements, and site needs;

- Improve modes of transport, loosening existing locational ties and reducing the importance of material transport costs as a spatial factor vis-à-vis other factors (like labor inputs, quality of product or service, speed and regularity of deliveries) and so alter spatial interrelationships; and

- Generate structural and hence intraregional and interregional spatial change through the rise of new functions (with new locational needs) and their technologies, with partial stagnation or total decline of activities dependent on older technologies or their adaptation to new conditions.

There have been changes in population size, structure, growth rates, distribution, incomes, skills, socioeconomic behavior and aspirations.

There has been urbanization which, especially in the developed world, has reached such high levels that researchers and policymakers perceive the "regional" framework to be of limited relevance by comparison with the problems, interlinkages, and "propulsive mechanisms" of larger cities.

There have been changes in international relations and in political and bureaucratic organization as policymaking and decisionmaking attempt to adjust to new stresses generated by the changing environment on the perceived governmental need to sustain national and regional development.

EXISTING RESEARCH

None of this complexity should deter our efforts towards establishing the proper extent and character of regional development, towards deepening our understanding of regional development processes and patterns, and towards finding more effective ways of harnessing regional potentials and of overcoming or reducing regional constraints in the interests of the very best living and working conditions for everybody everywhere.

What can IIASA studies of Integrated Regional Development (IRD) do to assist working towards these goals? The answer requires a brief assessment of the gaps that research effort to date has left in the field of regional development, and some outline of possible avenues for research exploration to fill these gaps, to reinterpret existing methods or to open up new vistas.

Hitherto, much international investigation has been initiated and executed within the framework of UN agencies. The most notable direct research into regional development issues was undertaken by the UN Research Institute for Social Development. The greater part of their findings, and further study of the themes that grew out of them, have been published under the editorship of Antoni R. Kuklinski. Other UN bodies engage in specific research themes that often shape the national environments for regional development especially in the developing world, but that do not directly result necessarily in the modernization of particular regions: labor-training, education and environmental quality programs (UNESCO, UNEP); capital and technology transfer and assistance (UNCTAD); and the location of specific industries (UNIDO).

These organizations have generated a vast collection of material on development and its spatial and structural properties that is extremely useful from methodological, conceptual, analytical, and practical viewpoints. It is largely due to their efforts that a more balanced, "integrated" approach to regional development has been brought about. They have demonstrated clearly that the problems of Africa, Asia, Latin America, and the Middle East need to be tackled in ways and with attitudes, aspirations, and aims that often differ significantly from those commonly accepted in the developed world, East or West, North American or European.

Thus it is important that any IIASA research, conceptual or practical field research, into the developing world is based on a clear understanding that the standards and methods applied may be quite distinct from those used in regional development in IIASA National Member Organization (NMO) countries.

The gaps in regional development research appear to be:

- Neglect of the mechanisms and control of the transmission of innovation or change through the spatial structure of regional systems from the "town-country" level to the interregional and national level;

- International trade factors influencing regional development as the international extension of the above phenomenon.

It is now essential to translate these very broad generalizations into definitive proposals. But, first of all, what do we mean by IRD?

DEFINITIONS

"Development" I would take to mean socioeconomic and cultural modernization involving structural shifts in activity and associated societal organization from lower stages (i.e. feudal-subsistence, nomadism, primary-extractive or limited industrial stages) to the higher stages (i.e. post-industrial stages) of society.

"Integrated" implies that the process of development is channeled, controlled, and coordinated to achieve and to maintain "harmonious" or "balanced" growth through careful dovetailing of economic, social, and technical action to achieve smooth structural change for the region as a whole and for each of its constituent units (town, village, subregion).

"Region" to me as an economic geographer is a term that, conceptually, applies to a relatively small number of spatial subdivisions of the national territory that represent a regional order for economic policy purposes generally intermediate between the nation and the largest, or first-order, administrative subdivisions of the country.

These grossly generalized definitions provide terms of reference for the ensuing discussion. In reality, however, one has to accept the enormous variation in spatial dimensions among the world's nations, and the marked interregional and international contrasts in the spatial intensity and structure of socioeconomic functioning. There is thus no easy way of achieving a meaningful regional subdivision. Let it simply be said that in very large states (Australia, Canada, Brazil, or the USSR) meaningful socioeconomic regions may in fact be subdivisions of certain large republics, provinces or states, or they may transcend them. Very small nations or city states like those in SE Asia and the Pacific, on the other hand, cannot stand individually as regions but may have to be 'grouped' or linked for purposes of analysis with nearby states with which they have close economic ties.

POSSIBLE AVENUES OF RESEARCH

These suggestions are an attempt to identify hitherto neglected fields for research that merit international investigation.

International Trade and Regional Development

It was hinted earlier that policymakers keen on regional development have often perceived regions designated for special development treatment as being more "closed" within the national and international system than they really are. In part this results from the ways in which rigid boundaries are drawn around the regions concerned. Research has neglected to place enough emphasis on the international trading relations of individual regions within a nation and how this stimulates, distorts, or hinders their development, and the effects on national development and functioning of the international trading relations (both direct and indirect feed-back effects) of all regions comprising the regional system of a nation.

There are two very practical reasons for promoting this particular theme. First, the developed countries are passing through a period of slow population and/or economic growth--a situation likely to continue for some years. This situation results from demographic trends and economic parameters like the long-term scarcity of investment capital. Structural modernization, while necessary to raise labor productivity, is slow because of capital scarcity. Second, the developing nations by contrast are passing through a period in which they have to cope with an enormous increase in their labor forces while, simultaneously, attempting to industrialize.

A myriad of variations lie between the two possibly opposing trends. On the one hand the developed nations will be, or are being, faced with various internal pressures like surplus capacity and labor. To protect themselves from external pressures that would exacerbate their problems--like cost inflation, competition, or dumping--they may raise, or at least not reduce, existing tariff and quota barriers. Clearly such action would operate to the disadvantage of developing countries in general and specific regions in the developed nations in particular. On the other hand, developing countries need to increase the export of those goods in which they have a comparative advantage. The labor-intensive industries (like clothing, footwear, and simple household or industrial products) could earn valuable overseas currency that could then be used to purchase the equipment and the raw materials or energy that will permit them to move up the industrialization "ladder". In the developed countries it is precisely the older, labor-intensive industries that are least efficient: any reduction in tariffs or other forms of protection would add to problems of unemployment, costs of retraining, and similar welfare schemes. But unless developed countries, and the regions within them where these problems are concentrated, restructure their economies, the developing countries will either face greater unemployment or reduced per capita income.

This forms the background. The research project could be organized as follows.

First, study could focus upon three groups of key trading commodities--primary energy (oil and gas), simple manufactured goods (textiles, footwear, metal goods), and agricultural produce for industrial processing.

Second, regions should be selected in differing stages of development and in developed, developing, and underdeveloped countries where impact of trade is a significant factor influencing regional economic structure. Such regions might be:

- Selected old coalfield/textile areas of the developed world--NW or NE England, The Ruhr, Łódź, select areas of the Soviet Central Industrial Region subject to modernization or restructuring processes;

- Developing oil regions in the Middle East with resource potentials but problems of industrialization;

- Emerging textile/footwear or metal goods industrializing regions in South and Southeast Asia where energy and market outlets might be problems;

- Agricultural regions in the developing world that are or might be attempting to develop industries on an agricultural base in the face of market competition from technological substitutes and highly intensive domestic farming in the developed world.

Third, each of the sample regions (in some cases nations, e.g. Hong Kong) would be examined in a systems analytic way to unravel the factors explaining present economic (industrial) structure and its intraregional spatial arrangement. Among such factors would be local resources and infrastructure, historic evolution, organizational structures as well as the effects of international capital technology and trade flows and of the international environment. Factors restricting development could be identified as could measures for removing restrictions on development.

Fourth, attention should be focused upon the possible lines of international-interregional cooperation to achieve more rapid integrated development in developing regions while simultaneously facilitating structural modernization of advanced or "mature" industrial-metropolitan regions. One aspect of this study might be to examine the success of international cooperation in adjacent regions for potential models of "overseas" cooperation.

If this project were considered too ambitious, the number and range of regional case studies could be reduced. One point to remember is the scale of regions: some developing and some developed countries are small enough to constitute "regions" in their own right, making data collection perhaps simpler, while others are so small that even development through the intensification of agriculture as a basis for "national" industrial development requires agreements with neighboring or nearby tiny territories upon the nature of agriculture-and-industry specialization and trading relations. The Association of South East Asian Nations is a good case in point.

The project could, however, be extended for a small number of regions to the study of international trade-technology-industry-agriculture-environment interrelationships.

The Territorial Production Complex (TPC) Concept and Regional Development

It may be a surprise to suggest a project to examine the application of the TPC concept to regional development in view of the recent completion of the Bratsk-Ilimsk TPC (BITPC) study by the Management and Technology section at IIASA, and the development of the concept in the rather specific environment of the USSR in general and of Siberia in particular.

However I would argue a case for such a project on several grounds:

- The BITPC study was an exercise in management and control, essentially of the use of regional resources for nationally oriented goals, and said very little about the evolution or theory of TPCs.

- The TPC concept has received relatively limited treatment as a method of regional development in international literature--even that edited by Kuklinski.

- While there is a vast amount of Soviet work published on TPCs must of this relates to typologies and hierarchies of TPCs or to case studies of specific Soviet regional structures, mainly in newer industrial areas, at a given point in time; there is much less Soviet work published on the evolution of TPCs through time and in space, the linkages within TPCs and between them and other regional economies or functional units--more specifically the mechanisms and directions of transmission of growth effects--and the application of the TPC concept to "nonvirgin" areas of the USSR, i.e. the European USSR where reconversion and adjustment of more complicated and older industrial regions has had to take place.

- The extension of this latter point is extremely important, namely, the potential application of the TPC as a mode of regional development in non-Soviet contexts, notably to the East European and other planned economies, to noncentrally planned developed economies, and to developing economies. Is the concept transferable to environments in which central planning is not characteristic? Is it adaptable to a variety of socioeconomic environments?

Why is the TPC an attractive concept? First, the TPC approach would give IIASA a powerfully integrating model which could draw upon the work and experience of the Management-Technology and Energy sections and yet which would yield its own original integration of developmental processes. Second, the TCP concept is ideally suited to applied systems analysis. It is a highly diversified concept, adaptable to a wide range of real regional environments, since it embodies a complicated matrix of "hierarchical orders" of scale and typologies of resource--agricultural-industrial-infrastructure (vertical/horizontal/diagonal) integration; and it focuses upon the interdependencies or linkages between economic, social, spatial, and technological factors. Third, the TPC concept lends itself to comparison and integration with the notion of the "industrial complex" developed by Chardonnet and Isard, so that it may be refined, along with concepts evolving in market economies, into a sophisticated and internationally (or universally) accepted mode of regional or spatial development.

This might require redesignation of the concept as the "regional complex approach", an advantage of this term being the elimination of the word "production" which tends to slant analysis and application of the TPC concept away from infrastructure, tertiary, and quaternary functions that become more important with development.

How could a project on "regional complex approach to development" be organized? I suggest the following research stages:

- Conceptual stage--an analysis of the conceptual and methodological evolution of the TPC and industrial complex concepts, their refinement and extension through time.

- Methodological stage--an assessment of the regional complex approach as a set of models for regional development strategies, paying attention also to any modernization of the concept that may be necessary in the light of the emergence of post-industrial societies, the existence of diversified socioeconomic systems and "control" mechanisms, and the leakages through interregional and international trade.

- Practical stage--the selection of a sample of regions, highly developed (for conversion), developed, developing, or underdeveloped, for application of the regional complex approach model, having due regard for the international as well as the national context of the regions concerned.

PARTICIPATION IN THE PROJECTS

At present I am Chairman of the International Geographical Union Commission on Industrial Systems. As an organization, we are extremely interested in the industry and industry-related aspects of regional development problems. Hence the Commission may be able to offer some research support for the projects outlined. At present this would have to be mainly through organizations for which Commission members are working and in the form of limited research time. Since the Commission has virtually no budget it must look to national or UN organizations or to IIASA for financial support. In modest amounts--for research time, assistance, and typing, however--such support could produce significant results because of the large membership of the Commission and its worldwide regional spread: currently the Commission has 35 members drawn from:

Africa:	Nigeria (1), South Africa (1)
Asia and Middle East:	India (1), Pakistan (1), Hong Kong (1), Japan (1), Israel (1), Thailand (1)
Australasia:	Australia (1), New Zealand (1)
Europe and the USSR:	Belgium (1), Czechslovakia (1), Denmark (1), France (1), FRG (1), GDR (1) Hungary (1), Italy (1), The Netherlands (1), Poland (1), Rumania (1), Switzerland (1), Sweden (2), UK (2), USSR (2).
Latin America:	Brazil (1), Chile (1), Venezuela (1).
North America:	Canada (2), USA (2).

The majority of members are academic teaching or research staff in universities in their respective countries, though a small number also work for the Academies of Science (in the USSR and Rumania) and for UN agencies (in Latin America); several have acted as government consultants.

Operations Research Methods for IRD

Rolf Funck, Gert Kautt, and Gerhard Rembold

INTRODUCTION

For a number of years a large part of regional science work has been the developing of operations research methods for regional studies. Among these methods, optimizing procedures, especially of the linear programming type, have been the main interest of regional economists. Not very many of the models designed to produce optimum values for such variables as income, employment, or investment of a region or a system of regions have actually been applied for this purpose. The reasons are twofold. Firstly, simple as the basic structure of such models may be, the number of variables and, therefore, the data requirements are usually very large, and can scarcely be met. This is due to a continuing lack of multisectoral, multiregional disaggregation of the existing information as well as the continuing scarcity of funds needed to produce the information required. Secondly, public awareness of the social importance of regional variables--ecological, behavioral, infrastructural--has grown considerably in recent years, calling for inclusion of these in regional, and interregional models, thus making them more complicated, and even more data starved. Similar statements can be made on other operational research methods, such as game theory, and graph theory. The latter has been rediscovered as a regional research tool only very recently, although the classical question in graph theory, the transport problem, is basically a regional one.

As a result, regional scientists have been more concerned with the mathematical structures of regional models than with the socioeconomic structures of regions. The term "operations-research regional science" (Funck, 1975) characterizes the dominance of this particular approach to regional phenomena in the 1960s and early 1970s.

For these reasons and because of the lack of interest of actual decisionmakers in elegant but unusable models, regional scholars interested in the scientific regional decisionmaking, have concentrated more on problems manageable from the modeling, the data, and the implementation points of view. A politically relevant scientific problem is not the optimum system of regions but the most efficient choice among available systems. This approach calls for the application of operations research methods in policy-sensitive models.

I will now present a problem and its solution, in which operations research methods have been used in the preparation of regional decisionmaking. The problem is on the interregional, national level, and the solution is based on graph-theoretical approaches.

THE DETERMINATION OF REGIONAL DEVELOPMENT POLES

The concept of "spatial growth" or "regional development poles" of Perroux (1950), Boudeville (1968), Streit (1971), Parr (1973), and others, so far can not be used as a basis for decision-making in regional development policies. In particular, the concept lacks statistical verification. It is the aim of a research project currently being carried out at the University of Karlsruhe, under the sponsorship of the German Research Association, to elaborate a computational method for the identification of regional development poles, and of the determinants of regional development potentials (Funck, et al., 1976; Rembold and Kautt, 1976).

The following questions will be answered:

- Which regions in the FRG can be characterized as development poles due to above average input and output dependencies within the framework of the interregional commodity flow matrix?

- To what extent do regionally specific natural resources, infrastructural components, or the sectoral composition of production determine the structure and intensity of input and/or output dependencies?

- Can key sectors of production or key components of infrastructure be defined, that, if available in abundance, would determine a region to be a development pole?

Based on their sectoral structure and the degree of intensity of the input and output relationships, classes of development poles are defined. These correspond with the classes of interregional delivery values. Following a suggestion by Czayka (1972), the computational determination of regions characterized as development poles is carried out with the aid of a graph-theoretical algorithm, that evaluates the structure of the national interregional commodity flows. I wish to describe this algorithm and the empirical results of determining development-pole classes briefly. Further cluster analysis will determine the development pole characteristics of the production structure, the infrastructure, and the structure of natural resources. Finally, factor analysis will be applied to identify the key components of the regional infrastructure. Thus, by deriving coefficients for key sectors of production from the input-output tables (see Eisenhammer, 1974; Laumas, 1975), strategic variables are made available to provide efficient regional development policies.

The statistical data used in the determination of regional development poles of the FRG include the values of commodity flows between 79 regions. From original data collected by the Statistisches Bundesamt (1972), the quantities of goods shipped between regions in 1970 were aggregated sectorally and weighted with average price figures taken from foreign-trade statistics. The 79 regions were determined based on the spatial statistical units for regional projections of the development plan of the Federal highway system for 1971-1985, developed by the Institut für Landeskunde, Bad Godesberg (see Figure 2). The sectoral subdivision consist of the eight commodity producing sectors out of 14 sectors used in spatially nondifferentiated input-output tables prepared for the FRG by the Deutsches Institut für Wirtschaftsforschung, Berlin (Krengel, et al., 1972).

In preparing the matrix of the national interregional commodity flows, a number of statistical problems arose: to begin with, problems of aggregation and assignment resulted from the statistics on commodity transport not being available within the 79 regional subdivisions, but in a subdivision into 76 spatial units that only partially coincide with the desired regionalization. Secondly, only volume data are listed (in tonnes of freight). Thirdly, a double counting of reloaded traffic, resulting in an "over-weighting" of regions with embarkation or unloading points along the inland waterways, with airports, or reloading stations between highways and railroads cannot be avoided. Fourthly, difficulties result from the fact that statistics on commodity transport do not include short haul transport: this has only minor effects on the analysis of interregional interrelationships carried out at a national level.

The recomputation of data to the 79-regions subdivision made it necessary to go back to the original data stored at the Federal Office of Statistics of the FRG. The data collected there are volumes of 169 types of goods and the flows between them in 1970 for 564 counties. 164 of the 169 types of goods are from the commodity producing areas, and had to be assigned to the 8 sectors mentioned. Moreover, for the analysis of market interrelationships of the inputs and outputs of each region, it is necessary to consider the monetary values as well as quantities of commodity flows. Since no statistics of absolute prices exist for the relevant commodities, the calculation of approximate prices was necessary. Statistical information was taken from foreign-trade statistics, where in detailed subdivision by commodities, exports and imports in both monetary and quantitative values are listed. By dividing the export values--in some cases the import values--by the respective quantities, the "prices per tonne transported" were determined.

The information and recomputation of statistical material has already been used in preparing the input-output model of the Total Interregional Model for the FRG (see Funck and Rembold, 1975, and the references given therein).

For the year 1970, the matrix of national interregional delivery flows for the FRG is a complete (79 × 79) matrix, in which, except for the diagonal, positive deliveries are shown for all regions. By means of traditional methods of determining key sectors based on input-output analysis, no statements about key regions can be derived in the interrelationships of these flows. It is not possible to make any assumptions concerning production techniques since the deliveries are determined through trade policies as well.

A simple classification of the regions would be, for example, on the basis of the total quantities of delivery, or receipt, respectively. This classification cannot provide information on the importance of individual regions within the interregional flows. By transforming the flows into graphs one can gain such information, thus providing the possibility of classifying the regions by both the absolute quantities of delivery and receipt, and their interrelationships.

Formally, interrelationships of national interregional commodity flows are determined by a set of discretely distributed regions, between which a three-valued mapping is defined. When transforming the interrelationships of national interregional delivery flows into a graph, the regions can be assigned to the vertices, and the monetary, weighted quantities of goods delivered among the regions can be assigned to the weighted directed arcs of delivery.

The following is a definition of a graph of delivery interrelationships (see Rembold and Kautt, 1976):

D1: Graph of Delivery Interrelationships

Let $G = \{V,A,\alpha,\omega,\ell\}$ be a weighted graph of delivery interrelationships.

where $V = \{v_\ell,\dots,v_n\}$ is the set of regions and

$A = \{a_\ell,\dots,a_m\}$ is the set of arcs of delivery.

The mapping $\alpha(a_i)$ is called the delivery region of a_i and

$\omega(a_i)$ the receiving region of a_i.

Since $\alpha(a_i) = v_\ell$ and $\omega(a_i) = v_k$, the delivery arc a_i can also be termed as tuple (v_ℓ,v_k). The mapping $\ell(a_i)$, or $\ell(v_\ell,v_k)$, or $\ell_{\ell k}$ gives the monetary value of deliveries from $\alpha(a_i) = v_\ell$ to $\omega(a_i) = v_k$.

The theory-of-graphs formulation of delivery interrelationships is the basis for the algorithm to be described here, that assigns all regions to so-called classes of development poles. Classification is according to the monetary value of deliveries among the regions. For each class of delivery flows, the development pole is identified.

D2: Development Pole

A development pole within the subgraph $\bar{G}$ of delivery interrelationships stands for the minimum possible subset $DV_{min} \subset V$ of the regions for reconstructing subgraph $\bar{G}$ successively so that only after all delivery arcs originally ending in this region have been taken into account, can the arcs of delivery beginning in this region be integrated into the subgraph.

D3: Subgraph of Delivery Interrelationships

Let a graph $\bar{G} = \{V, \bar{A}, \alpha, \omega, \ell\}$ with $\bar{A} \subset A$, where $A = \{a_i / \ell(a_i) >$ lower bound of a class$\}$, be called a subgraph of delivery interrelationships.

Accordingly, the development poles of the delivery interrelationships are the smallest subsets of regions from which all remaining regions can receive deliveries directly or indirectly. A region can start delivering only after taking into account all deliveries received. The following algorithm will show that, except for regions characterized as sources or sinks, development poles are created by the same subset of regions that can generate receipt and delivery structures.

The algorithm for the determination of classes of development poles was programmed in ALGOL60 for the computation of the interrelationship of national interregional delivery flows.

Module 1: Determination of the subgraph of delivery interrelationships and its adjacency matrix.

- Step 0: Select a classification that subdivides deliveries by monetary value. Classes are each given by the lower bounds.
- Step 1: Form the subgraph of delivery interrelationships of the respective class; if regions with development-pole characteristics have been identified, then eliminate the arcs of delivery beginning or ending in these regions.
- Step 2: Form the adjacency matrix of the assigned qualitative subgraph of delivery structure derived from the subgraph of delivery interrelationships.

The following definition is for the adjacency matrix of a qualitative subgraph of the delivery structure, assigned to the subgraph of delivery interrelationships:

D4: Adjacency Matrix of the Assigned Qualitative Subgraph of Delivery Structure

The (n × n) matrix $B(\bar{G})$ with the elements

$$b_{\ell k} = \begin{cases} \ell, \text{ if there exists an arc of delivery} \\ \text{between } v_\ell \text{ and } v_k, \\ \text{with } \ell(v_\ell, v_k) > 0, \\ 0, \text{ otherwise} \end{cases}$$

derived from a subgraph of delivery interrelationships is called the adjacency matrix of the assigned qualitative subgraph of delivery structure.

Module 2: Determination of sources and sinks.

- Step 0: Generate the total sums of rows and columns in the matrix $L(\bar{G})$ of the evaluated subgraph of delivery interrelationships.
- Step 1: Identify, by comparing column- and row-totals, those regions having the characteristics of sources or sinks, respectively.

D5: Direct successor region or predecessor region

Set $S(v_k) = \{v_\ell / v_\ell = \omega(v_k, v_\ell) \wedge v_k = \alpha(v_k, v_\ell) \wedge \ell(v_k, v_\ell) > 0\}$ is called the set of direct successor regions of region v_k, and set $P(v_k) = \{v_i / v_k = \omega(v_i, v_k) \wedge v_i = \alpha(v_i, v_k) \wedge \ell(v_i, v_k) > 0\}$ is called the set of direct predecessor regions of region v_k.

Then, regions are designated as sources or sinks according to the next section.

D6: Source and Sink

A region v_k whose set of direct predecessor regions $P(v_k) = \phi$ and whose set of direct successor regions $S(v_k) \neq \phi$, is designated as source. By analogy, a region v_i is designated as sink, if $S(v_i) = \phi \wedge P(v_i) \neq \phi$ applies. It follows from the evaluated matrix of delivery interrelationships, $L(\bar{G})$, that region v_k is a source, if the following applies;

$$\sum_r \ell_{kr} > 0 \quad \wedge \quad \sum_s \ell_{sk} = 0 \quad .$$

(total of row k) (total of column k)

Region v_i is a sink, if the following applies in L(G):

$$\sum_t \ell_{ti} > 0 \quad \wedge \quad \sum_u \ell_{iu} = 0 \quad .$$

The next step is to determine the strongly connected fragments of the subgraph of delivery interrelationships.

D7: Strongly Connected Fragments

Two regions v_ℓ and v_k are designated as being strongly connected ($v_\ell \sim v_k$) if v_ℓ can be reached from v_k, and v_k from v_ℓ, too. The set of regions V of a subgraph of delivery interrelationships $\bar{G}$ dissociates completely into disjunct subsets $ZK_\ell, \ldots, ZK_p$, called the strongly connected fragments of G.

The following applies

$$\bigcup_r ZK_r = V \wedge ZK_t \cap ZK_s = \phi, \quad (t \neq s) \quad .$$

With D8: Accessibility

A region v_k is designated as accessible in $\bar{G}$ from v_i, if there exists a path of delivery arcs $W(v_i,v_k)$ in $\bar{G}$, with a delivering region v_i and a receiving region v_k. In addition, each region is accessible from itself.

With D9: .Path of Delivery Arcs and Circuit of Delivery Arcs

A set of delivery arcs $W(v_i,v_k) = \{(v_i,v_\ell)(v_\ell,v_{\ell+1}),\ldots, (v_{\ell+n-1},v_{\ell+n})(v_{\ell+n},v_k)\}$, contained in the subgraph $\bar{G}$ of delivery interrelationships, is called a path of delivery arcs from region v_i to region v_k, where $W(v_i,v_k) \subset A$ applies. If the set $W(v_i,v_k)$ does not contain any identical delivery arcs, and if $v_i = v_k$

applies, then this path of delivery arcs is called a circuit of delivery arcs.

Determination of all strongly connected fragments can be carried out on the basis of the accessibility matrix $E(\overline{G})$. All the regions therein, pertain to a strongly connected fragment, for which the structure of rows is identical in the accessibility matrix $E(\overline{G})$.

D10: Accessibility Matrix

The $(n \times n)$ matrix $E(\overline{G})$ assigned to a graph $\overline{G}$, with the elements

$$e_{ik} = \begin{cases} 1, \text{ if } v_k \text{ can be reached from } v_i \\ 0, \text{ otherwise} \end{cases}$$

is called the accessibility matrix of graph $\overline{G}$.

It is recommended, however, for computational reasons, to employ Module 3 in cases with extensive subgraphs of delivery interrelationships:

Module 3: Determination of all strongly connected fragments

- Step 0: Choose any region v_k in the adjacency matrix $B(\overline{G})$ of the assigned qualitative subgraph of delivery structure, and determine, by iteration, all direct and indirect successor regions as well as, by analogy, all direct and indirect predecessor regions. The intersection of all successor regions with the set of all predecessor regions and the selected region v_k yields a strongly connected fragment.
- Step 1: Eliminate in adjacency matrix $B(\overline{G})$ all rows and columns assigned to the regions pertaining to the strongly connected fragment just found, and repeat Step 0 for the reduced adjacency matrix; if, by the elimination of rows and columns, no more regions can be assigned to a strongly connected fragment in adjacency matrix $B(\overline{G})$, the module is finished.

D11: Indirect Successor Regions or Predecessor Regions

The set of all regions accessible from v_i, minus the set $S(v_i) \cup v_i$ depicts the set of indirect successor regions; according conditions apply to the set of indirect predecessor regions.

In continuing computation, a circuit matrix $Z(\overline{G})$ has to be formed for each strongly connected fragment.

D12: Circuit Matrix

A $(q \times n)$ matrix $Z(\overline{G})$, where the head row lists all regions $v_1,\ldots,v_n$, and where the head column lists all continuously numbered direct circuits $Z_1,\ldots,Z_q$ contained in a graph $\overline{G}$, with the elements

$$z_{ij} = \begin{cases} 1, & \text{if region } v_i \text{ is contained in circuit } Z_i \\ 0, & \text{otherwise} \end{cases}$$

is called a circuit matrix of graph $\overline{G}$.

Module 4: Determination of all circuits of delivery arcs

- Step 0: All circuits of delivery arcs of each strongly connected fragment must be determined by means of a branch and bound module, starting from arbitrarily chosen regions v_k that each yield the root of a tree, and successively attaching the successor regions to the tree as branches. The branching of each tree continues until either the region representing the root and the successor region last reached, are identical, or until there is no further admitted successor region. Regions that are either not listed yet on the branch under consideration, or have not occurred previously as root of an already existant tree are admitted as successor regions for a tree. Each region becomes the root of a tree once only.
- Step 1: All known directed circuits of a strongly connected fragment are listed in the circuit matrix $Z(\overline{G})$.

The circuit matrix represents the initial data for determination of the development poles, found by means of Modules 5 and 6. Both modules again have a branch and bound structure. According to Figure 1, the vertices of a tree are each assigned to the splitting steps of the circuit matrix.

splitting step n = 0

splitting step n = 1

splitting step n = 2

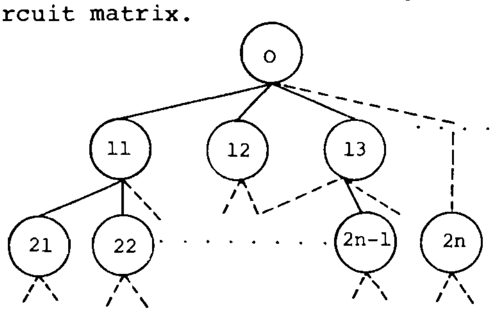

Figure 1. Splitting steps.

Module 5: Determination of the minimum number of regions contained in all circuits of delivery arcs

- Step 0: Equate the minimum with (number of rows in the circuit matrix) - 1, and assign this circuit matrix to the splitting step n = 0. Proceed to Step 1.

- Step 1: Add up all columns and sort the total according to their amount; in cases of equality, in accordance with the assigned numbers of regions v_k. Proceed to Step 2.

- Step 2: Compare the highest, not yet marked column total, with the number of rows in the circuit matrix assigned to the splitting step n, if the column total = the row total; then

  for $n \geq 2$, (1) put minimum = n + 1,

  (2) return to splitting step n - 2 and begin with Step 3; or

  for $n < 2$, (1) put minimum = n + 1, and finish with modules;

  otherwise: proceed to Step 3.

- Step 3: In the case where splitting step n (minimum - 1) applies, and if not all column totals of the matrix are marked on splitting step n, then form a submatrix for the splitting step n - 1 by selecting and eliminating the region with the highest, not yet marked column total, and by eliminating all circuits of delivery arcs containing this region, mark the column total assigned to the selected region in the submatrix on splitting step n, and go to Step 1. Otherwise return to splitting step n - 1, if splitting step n - 1 < 0 applies, and finish module; otherwise start with Step 3.

Module 6: Determination of regions that are elements of a development pole and of the class of development poles.

- Step 0: In accordance with Module 5, the hierarchy of splitting steps is completed up to splitting step n = minimum - 1.

- Step 1: Find in the splitting step hierarchy, those vertices on splitting step n = minimum - 1, that contain regions for which the column total = the number of rows.

- Step 2: Find on the branches whose vertices fulfill the conditions cited in Step 1, all regions that were eliminated from the submatrices in the previous splitting steps.

- Step 3: For each branch, combine the set of all regions found in Steps 1 and 2 with a development pole, and unite all development poles, including sources or sinks with an above-average dependency of deliveries, in a class of development poles.

With the identified regions assigned to a class of development poles, the algorithm is repeated with Module 1 for the next lower class of delivery flows. These iterative computations are run until the development poles of all classes of delivery flows are found and where, hence, all regions are assigned to one of the classes of development poles.

Figure 2 reflects the empirical results applying to the FRG, as found for 1970. The following subdivision was chosen to classify the delivery flows of goods:

Value of lower bound of delivery arc 10^6 DM/year)	Class of Development Pole
700	I
450	II
300	III
150	IV
100	V
75	VI
50	VII
25	VIII
10	IX
0	X

A number of test computations using alternative classifications, for example 8 or 13 classes, showed the ranking sequence in the assignment of regions to the classes of development poles to be absolutely stable.

The results of the classification of regions is fairly well in accordance with what one would guess, with several major exceptions (namely: regions 76 Munich, 53 Stuttgart, 49, 46 Rhein-Neckar, and 1 Berlin) all of which are in lower branches than they would be expected to be. (The isolated situation of West Berlin in the territory of the GDR probably accounts for the last.)

The question remains of whether the concentration of regional policy measures in development pole regions offers the best chance of advancing the hinterland through both strong forward and backward linkages, or whether, on the contrary, a widening of the

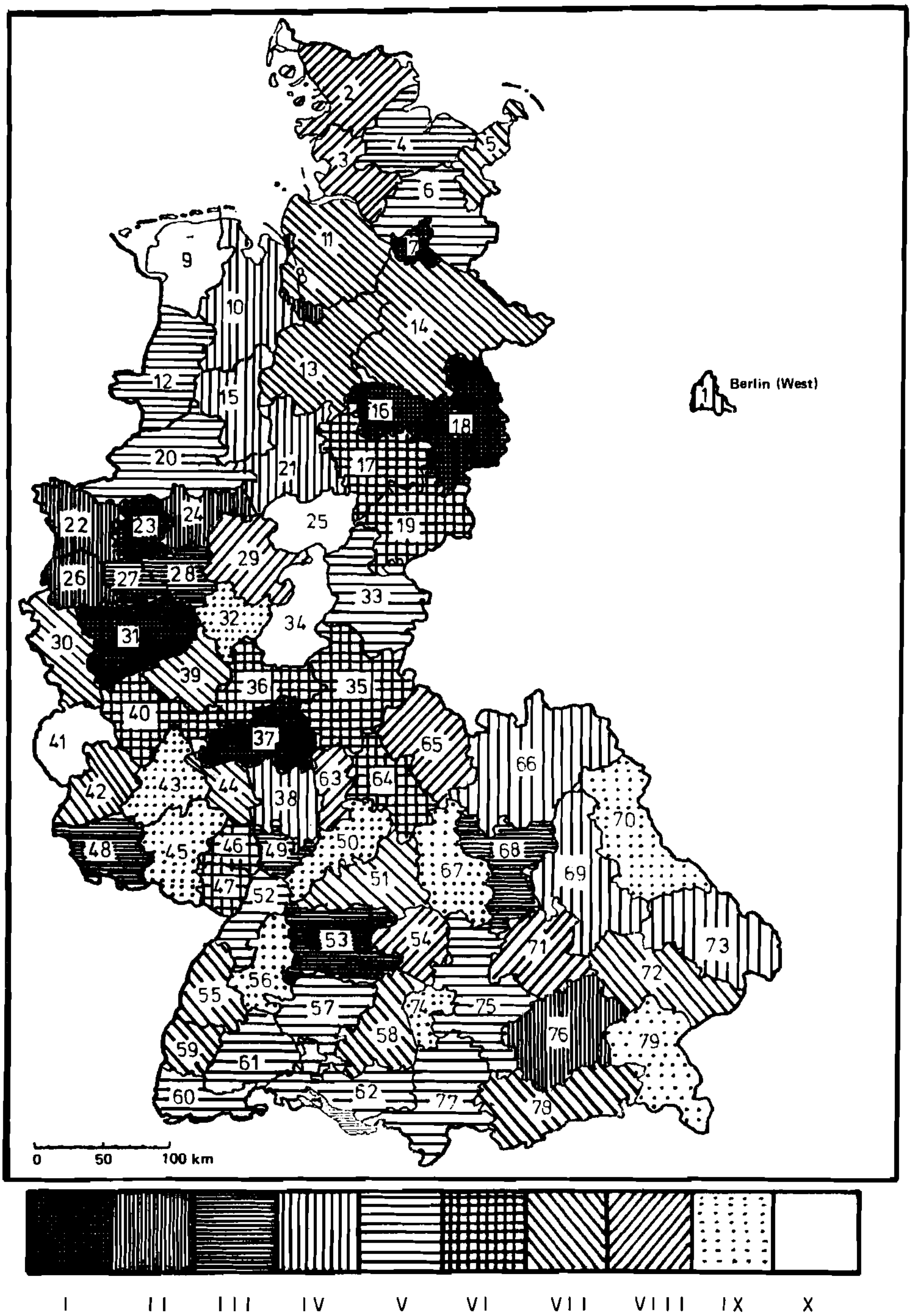

Figure 2. FRG classes of development poles for the year 1970.

development gap will result. At any rate, the method presented here can help prepare regional decisionmaking on this by determining where the development pole regions are located, and how strong their positions in the system of interregional delivery flows are.

CONCLUSIONS

If operations research methods as a problem-solving device in the preparation of regional decisionmaking are to survive, a growing awareness is necessary of the needs of practical planning. The application presented above is among a number of other studies in which we have tried to employ operations research approaches to problems of this kind. Of particular interest may be those which are directed, on the regional level, towards the optimum design of infrastructure networks (see, e.g. Böttcher and Rembold, 1975; Funck and Böttcher, 1976), or which deal with the evaluation of projects on the intraregional level, (see, e.g. Funck, et al. 1975). Here analytical measurements of project effects are being combined with political judgments obtained in formal procedures, in order to determine a social evaluation of alternative decisions.

REFERENCES

Böttcher, H., and G.H. Rembold (1975), *Optimization Model for a Regional System of Solid-Waste and Waste Water Disposal Considering Legal Pollution Standards*, Discussion Paper 3/75, Institut für Wirtschaftspolitik und Wirtschaftsforschung der Universität Karlsruhe, Karlsruhe.

Boudeville, J.R. (1968), *L'espace et des pôles de croissance. Recherches et textes fondamentaux*, Bibliotheque d'Economie Contemporaine - Etudes I.S.E.A., Paris.

Czayka, L. (1972), Qualitative Input-Output-Analyse; Die Bedeutung der Graphentheorie für die interindustrielle I-O-Analyse, *Schriften zur wissenschaftlichen Forschung*, Vol. 42, Anton Hain, Meisenheim am Glan.

Eisenhammer, D. (1974), *Motorische Produtions-Sektoren im Rahmen regionaler und nationaler Input-Output-Tabellen*, Schmitt & Meyer, Würzburg.

Funck, R. (1975), Regional Science: Frontiers or Boundaries? Panel discussion of the Third Advanced Studies Institute in Regional Science, in John B. Parr ed., *The Regional Science Association Papers 34*, The Regional Science Association, Philadelphia.

Funck, R., and G. Rembold (1975), A Multiregion, Multisector Forecasting Model for the Federal Republic of Germany, in John B. Parr ed., *The Regional Science Association Papers 34*, The Regional Science Association, Philadelphia.

Funck, R., et al. (1975), *Prioritäten für den Ausbau des Hamburger Schnellbahnnetzes*, report by the Institut für Wirtschaftspolitik und Wirtschaftsforschung der Universität (TH) Karlsruhe, the Institut für Verkehrsplanung und Verkehrstechnik der Technischen Hochschule Darmstadt, and the Institut für Verkehrsplanung und Verkehrswesen der Technischen Universität München.

Funck, R., and H. Böttcher (1976), *Optimierungsverfahren für regionale Kommunikationssysteme*, unpublished Interim Paper, Universität Karlsruhe.

Funck, R., G. Rembold, and G. Kautt (1976), *Operationalisierung des räumlichen Wachstumspolkonzeptes als Basis einer effizient zu gestaltenden Entwicklungspolitik*, unpublished Interim Report, Universität Karlsruhe.

Krengel, R., et al.(1972), Jährliche nominale Input-Output-Tabellen und Importmatrizen für die Bundesrepublik Deutschland 1954 bis 1967, *Beiträge zur Strukturforschung* No. 21, Duncker & Humbolt, Berlin.

Laumas, P.S. (1975), Key Sectors in Some Underdeveloped Countries, in *KYKLOS, Internationale Zeitschrift für Sozialwissenschaften*, Vol. 28, Fasc. 1, Kyklos-Verlag, Basel.

Parr, J.B. (1973), Growth Poles, Regional Development, and Central Place Theory, in Morgan D. Thomas ed., *The Regional Science Association Papers 31*, The Regional Science Association, Philadelphia.

Perroux, F. (1950), *L'économie du XX^e siècle*, Presses Universitaires de France, Paris.

Rembold, G.H., and G. Kautt (1976), *A Method for the Empirical Determination of Classes of Regional Development Poles Applying to the Federal Republic of Germany*, Discussion Paper 1/76, Institut für Wirtschaftspolitik und Wirtschaftsforschung der Universität Karlsruhe, Karlsruhe.

Statistisches Bundesamt, ed. (1972), *Fachserie H*, Reihe 1-4, Verkehrsbewegungsstatistik, Wiesbaden.

Streit, M.E. (1971), Regionalpolitische Aspekte des Wachstumspolkonzepts, in *Jahrbuch für Sozialwissenschaften*, Vol. 22, No. 2, Vandenhoeck & Ruprecht, Göttingen.

Suggestions for Future IRD Studies

Walter B. Stöhr

In order to be of maximum benefit and to use the advantages of IIASA best, integrated regional development (IRD) studies should be oriented towards

- Universal objectives and universally felt human needs in their regional (spatial) dimension;
- Universally effective change agents;
- Widely applicable characteristics of regions (typical regions by criteria of homogeneity); and
- Development of widely applicable analytical techniques and models.

UNIVERSAL OBJECTIVES AND UNIVERSALLY FELT HUMAN NEEDS IN THEIR REGIONAL (SPATIAL) DIMENSION

The lower down to the individual or the small group level you go, the more universal are the basic needs and human objectives. The IRD studies might focus on characteristics of the quality of life (as dependent variables) such as levels of income, access to (quantity and quality) of employment opportunities, access to basic needs (public and private services, education, health facilities, etc.), functioning of social networks, and spatial distribution of production facilities.

The analysis should be conducted at at least two levels of spatial disaggregation:

- At the interregional level for selected countries and
- At subregional levels for one selected region of that country.

Disaggregation should also be made by social strata, age groups of different mobility, etc. in order to show differences in access to basic needs in as realistic a way as possible and to avoid meaningless averages and abstractions as much as possible.

UNIVERSALLY EFFECTIVE CHANGE AGENTS

Examples of the change agents that operate today in all developed countries and in the future increasingly in developing countries also are:

- Large-scale schemes of international or national economic and political integration,
- Large-scale changes in transportation systems (rapid road, rail, or air transportation systems, etc.),
- Large-scale changes in energy systems (shifts from non-renewable to renewable sources of energy, etc.), and
- Large-scale industrialization schemes such as territorial industrial complexes (in centrally planned economies) and growth centers (in market and mixed economies).

These universal change agents (or exogenous factors from the standpoint of a regional community) have very different impacts upon individuals and small-scale groups over space. The objective of the project would be to analyze the spatial dimension of these variations. Unless we can evaluate them, our only criteria remain the usual abstract macro-variables (national or regional product and income, trade balances, transport flows, etc.) that usually are of only very indirect relevance to the well-being of individuals and small groups. Their relation to equity in access to basic needs is in fact usually grossly disquised.

To give an example for the first change agent, large-scale integration schemes; analytical methods and models might be developed to clarify the spatial determinants by which integration schemes create differential advantages or disadvantages for territorially organized communities at different scales (what is the weight of determinants such as access to the new common market, distance from urban centers, initial level of development, sectoral structure of individual localities or areas, pertinence to the formal or informal sector, etc.).

WIDELY APPLICABLE CHARACTERISTICS OF REGIONS (TYPICAL REGIONS BY CRITERIA OF HOMOGENEITY)

In order to facilitate comparability, it would be advisable to study areas of comparable characteristics, such as depressed areas in individual countries. Most industrialized countries have made substantial strides to promote development in their depressed areas and the change agents mentioned in the last section have been among the major strategy elements applied. It would be very valuable to be able to make a systematic comparative evaluation of the effects of these strategies upon actual living conditions in the areas concerned. It is particularly important at present when a foreseeable decline in aggregate economic growth rates may require a review of policies for depressed areas in search for the most effective strategies for obtaining specified goals. While the majority of studies may initially be located in industrialized countries the results could be useful to developing countries which, for reasons of national economic constraint, may be able to tackle depressed area problems effectively only at a later stage.

Another type of region might be highly urbanized and industrialized areas in individual countries. Here more complex analytical techniques would probably be required because of the greater complexity of economic and social structures and the complex infrastructure networks in these areas often dating from very different periods. On the other hand, here problems would be dealt with of areas in which a major part of the population of the particular countries live. A sideline might be that common use of the broad data material accumulated might be feasible for the Human Settlements and Services Area of IIASA.

Most of the case studies for the former Large Organizations Program of IIASA have been applied to the third type of region, namely resource frontiers. Comparison between these case studies seems difficult however, because of greatly varying data sets and (to my knowledge) the absence of a common methodology of analysis. This would be very important for IRD studies.

DEVELOPMENT OF WIDELY APPLICABLE ANALYTICAL TECHNIQUES AND MODELS

This is the priority task for any IRD studies at IIASA. Analytical methods and models useful for clarifying functional relations in the problem areas mentioned should be developed and tested in various case studies. Along with the case studies, the analytical methods and models should then be improved and serve as a major output at the end of such a program. They could later be applied in other National Member Organization (NMO) and nonmember, particularly developing, countries. IIASA could make a very important contribution to the application of modern analytical techniques and methods to the solution of problems of actual regional communities. The development of techniques and models could be done by a small group at IIASA, while the case studies could be carried out in a more decentralized form by cooperating institutions or scholars in NMO countries. Models already developed in such countries should of course be incorporated into the IIASA IRD studies.

Some Comments on IRD Studies at IIASA

Yoshikasu Sawaragi

GENERAL COMMENTS

During the past five years, IIASA has conducted systems analysis on several large-scale regional development programs, among which the Tennessee Valley Authority (TVA) in the USA and the Bratsk-Ilimsk Territorial Production Complex (BITPC) in the USSR are typical. This year, the Management and Technology team is going to study two projects in Japan, the Shinkansen and the Kinki Region projects.

The research projects in the past, carried out by multinational and multidisciplinary research staffs, have succeeded in clarifying the effectiveness of systems methodologies for analyzing planning, management, and organizational aspects of large regional programs. Experience of various regional systems with different socioeconomic characters, has, to some extent, shown the universality or transferability of systems methodologies.

In future integrated regional development (IRD) studies at IIASA, the following principal factors should be taken into consideration:

- In reality, each region is unique; it is different from other regions geometrically, geographically, historically, culturally, socially, economically, and so on. To what extent then, can systems methodologies and experiences be transfered from one region to another? This question should always be kept in mind--the universality concept should not be pursued beyond its limit.

- Planning, management, and decisionmaking in a region has always been and should be, more or less, the preference of its inhabitants. Systems methodologies for enhancing information exchange among people and then getting people's consensus are to be developed more in depth. Fundamental concepts and technologies for assessing planning and evaluation of management are also needed.

- The planning or synthesis aspect should be stressed rather than the mere diagnosis or analysis aspect. Systematic approaches for incorporating experiences, value systems, planning knowhow, by interactive use of computer information processing ability, will play essential roles in systems synthesis.

SHORT OVERVIEW OF IIASA/JAPAN COOPERATIVE STUDY ON IRD SYSTEMS FOR THE KINKI REGION

General Objectives

Japan's economic growth during the last quarter of a century has made it one of the world's leading industrial nations. Owing to the paucity of natural resources and the limited land area, this development was achieved mainly by concentrating on industrial activities. As a natural outcome of this economic growth and concentration, many undesirable social problems have developed that now have come to public notice. Having created an industrialized region, we must now safeguard the environment and provide a satisfactory quality of life for its inhabitants. This entails taking into account not only the economy of the region but also aspects such as population, resources, land use, communication, and transportation. Without the aid of a systems-analytic approach, it is almost impossible to deal with such complicated problems.

We have selected the Kinki Region for a case study, since it is an economically important region in Japan. It is situated a little to the west of the middle of the Japanese mainland, and contains almost all of the ancient capitals of Japan, e.g. Kyoto and Nara. Approximately 18 percent of the socioeconomic activity of present-day Japan is concentrated in the Kinki Region, although its land area is approximately 10 percent of Japan. It is now facing serious problems of shortage of land and water resources, environmental pollution, and traffic and housing congestion. From the national point of view, it is still expected to play an important role in the future socioeconomic development of Japan. These factors necessitate comprehensive integrated regional planning for the Kinki Region.

In this cooperative study, it is expected that IIASA's unique facility of international collaborative network will play an important role in carrying out new methods and strategies for integrated regional management.

List of Research Tasks

All the tasks for the IIASA/Japan cooperative study on the Kinki Region can be classified into the following two categories:

- Category A: Integrated regional development (IRD) systems,
- Category B: Regional environmental management systems.

The tasks under each category are detailed in the Appendix.

List of Japanese Research Members

Organizer and principal investigator of Japanese research group:

(1) Y. Sawaragi, Professor at Kyoto University, Department of Applied Mathematics and Physics, Faculty of Engineering

General secretaries:

(2) S. Ikeda, Research associate of Kyoto University, Faculty of Engineering (IIASA Research Scholar at present)

(3) K. Ito, Research associate of Osaka University, Faculty of Engineering (IIASA Research Scholar previously)

Research members:
Kyoto University

- Faculty of Engineering

(4) Y. Nishikawa (5) T. Hasegawa (6) H. Tokumaru
(7) T. Sasaki (8) K. Inoue (9) T. Katayama (10) N. Sannomiya
(11) N. Adachi (12) H. Itakura (13) A. Udo

- Institute of Economic Research

(14) H. Onoe (15) F. Seo (16) K. Nakagami (17) T. Nakatani

- Faculty of Agriculture

(18) T. Kitamura

- Research Institute for Agricultural Accounting

(19) T. Yori

Osaka University

- Faculty of Engineering

(20) Y. Suzuki (21) T. Sueishi (22) K. Shoji (23) P. Pak
(24) K. Tsuji

Konan University

(25) H. Nakayama

Kobe University

- Faculty of Engineering

(26) S. Fujii (27) M. Sakawa

Ritsumeikan University

(28) H. Horiyama

IBM Japan

(29) T. Matsuzaki

PROJECT DEFINITION OF THE PARTNERSHIP PROGRAM BETWEEN JAACE AND IBM JAPAN

In order to enhance the research activities in the Kinki IRD program, the Japan Association of Automatic Control Engineers (JAACE, including staffs of Kyoto and Osaka Universities) and IBM Japan have recently agreed to develop a new comprehensive research project. The joint study started on 1 January 1977, under the Project Chairman, Y. Sawaragi, Department of Applied Mathematics and Physics, Kyoto University. Y. Nishikawa, Department of Electrical Engineering, Kyoto University, and T. Matsuzaki, Tokyo Scientific Center, IBM Japan, are the Project Managers.

The team includes Y. Nagao, Department of Transportation Engineering, Kyoto University, F. Seo, Institute of Economic Research, Kyoto University, Y. Suzuki, Department of Electrical Engineering, Osaka University, and several others.

At the end of February, a framework of the project was approved by the research members. The leading philosophy of the project is to be the "Enhancement of Amenity and Quality of Life" of the region. For evaluation of these, some measurable indicators are to be chosen in the next stage. The other principal objectives of the project are:

- Extraction and evaluation of regional characteristics and inhabitants' preference.

- Assessment of some past and future regional planning.

- Collection of reliable data and establishment of a regional data base.

- Development of systems and computer-assisted methodologies to support administrative decisionmaking. Application of new mathematical tools for structural modeling of the regional problematique and multiobjective regional planning will be especially stressed.

- Development of an integrated regional model to support diagnosis and future planning. Sectoral models on such items as population, industrial activity, urbanization, transportation, resources, food, energy, and environment will be included in the model.

Efficient utilization of computer systems techniques is an important concept in the project. The following outlines the basic concept and techniques:

- Interactive approach: In order to incorporate experiences, value systems, and planning knowhow into the integrated model, an interactive approach is essential. Model management, operation functions, and data operation management will be implemented in the computer system. An RJE (Remote Job Entry) terminal (IBM 3780) and an interactive terminal (IBM 3270) have already been installed.

- Display technology: In order to accelerate communication between planners, model developers, interested groups, and computer systems, such media as graphic display terminals, interactive terminals etc. will be fully utilized.

- Resource sharing: Among the research teams in Kyoto, Osaka and Tokyo, some resource sharing will be implemented by communication lines.

Appendix

Detailed Description of the Research Tasks

A1: A System Model to Seek Optimal Regional Development-- Y. Suzuki (20), K. Shoji (22), K. Ito (3), K. Tsuji (24)

The objective is to construct an integrated regional planning model for a specified region that seeks the desirable socioeconomic development pattern and strategies to realize it. In the model, various noneconomic aspects, such as environmental pollution and the shortage of water resources, are considered explicitly.

In the long-term integrated model, the scale becomes large and the burden on time and cost becomes too heavy to execute many trials. Analytical problems will also arise. To overcome these difficulties, we have adopted a hierarchical approach with two types of models. In both, the region and its surroundings are divided into several subregions and the region's future status is investigated in relation to the nation's future status.

In the upper stratum model, only the initial and final years are considered. A linear programming model has been used to determine the optimum allocation of industries, population, and social capital under several premises (e.g. GNP growth, accumulated capital investments, etc.). The model puts emphasis on operational characteristics and saving computational time, and can describe various socioeconomic development patterns under different premises in a form suitable for intuitive understanding.

The lower stratum model uses a more precise description, and suggests what kind of policies could be taken. The guidelines decided by the upper model are built in the objective function of the lower model. Demand-supply relations based on input-output tables are considered and annual optimum investment plans are determined by using a quadratic programming method. Although the lower model contains several elements analyzed by economics, it has been constructed especially for long-range planning and is not directed toward positivistic studies.

In developing these models, emphasis has been placed on the investigation of the real world, and the Kinki area has been chosen as a specific region. A simulation model has already been constructed and several preliminary studies carried out with it. Revision of the model, especially of the objectives and constraints, is now underway.

A2: Computer-Assisted Integrated Regional Development Planning (CAIRDP)--T. Matsuzaki (29), Y. Sawaragi (1)

The objectives are the identification of regional systems structure and goals of IRDP, an analysis of the requirement of a computer systems approach and concepts development to the solution, a feasibility study of applying modern technology of data processing and advanced methodologies, and implementation and institutionalization of the concepts (if possible). These will be carried out by cooperation between central and local governments, and universities and research institutions from May 1976 through May 1977.

A3: Development of Methodologies for Regional Data Collection and Management Systems and for Multi-Objective Planning--Y. Nishikawa (4), N. Sannomiya (10), H. Itakura (12), A. Udo (13), T. Kitamura (18), T. Yori (19)

During the last few years, this subgroup has been concerned with basic research projects on diagnosis and modeling of various regions, including Shiga-prefecture, Kyoto-City, etc., development of methodologies and algorithms for systems optimization and identification, and development of methodologies for data collection, including image processing of remote sensing data.

In addition, city officials, computer software specialists, and graduate students, have cooperated with the above members temporarily.

Basic Viewpoints

The principal aims of our research on a regional system are:

- To get correct data on the principal items of the system, and to process them so as to make observation of the current system status possible.

- To establish some indexes upon which a planning model can be constructed, i.e. to have fundamental indexes to evaluate the system.

- To construct a dynamical model that demonstrates the internal relationships among the principal system elements and could suggest a possible (favorable) status of the system in the future.

In order to construct a good regional system, we have to consider not only economic development or pollution problems, but the total quality of life (or welfare) in the region. First, what are the indexes for the quality of life, and how can we measure them? These are very basic and, at the same time, very tough questions.

We have to try to get some answers. Second, the system status is influenced by many factors, but will finally be regulated by land use in the system. So decision of an appropriate land use is a key point of the regional systems planning.

A Systems Methodology for Regional Data Collection and Management

Currently, various kinds of official statistics issued by the national and the regional governments are available. However, they are sometimes inconsistent in methods and results. Really reliable statistics are still lacking especially for regional items. For our modeling, correct and detailed data are needed regarding, for example, population, resources, nature status, land-use status, human-life activities, economics status, industrial activities, transportation, pollution level, and so forth. Our aim is to establish a computer-aided system for collection and management of those regional data. In addition to the conventional methods for data collection, we will use remote sensing and image processing techniques for fixing geometrical and geological status, especially the land-use status of the region.

Methodologies for Multiobjective Planning

The problem of regional planning is a typical complex of various subproblems, i.e. a so-called problematique. Methodologies for constructing a descriptive or dynamic model will be further investigated. Particularly, the indexes for evaluation and judgment of the total system status will be looked for. Our basic viewpoint is to consider the quality of life, and we will then regulate the economic and industrial growth to improve it. The quality of life would be measured by certain fundamental factors, such as social safety, healthiness, comfort, economic efficiency, etc. A case study has already been done by a member of the group in a relatively small town. Research will also be done for a practical methodology of multiobjective planning. Our approach is either to start with a conventional single-objective mathematical programming technique and to convert some constraints into objectives, or to develop a method for bicriterion subproblems and to coordinate subproblems for a total optimization.

Case Studies

Three regions of different levels are now in our project, namely Prefecture level: Shiga (or Kyoto)-prefecture, Large-city level: Kyoto-City, Small-town level: Shinasahi-cho in Shiga-prefecture. Consideration of the whole Kinki district will also be an object of other groups.

A4: A Land Use Model by System Dynamics--T. Hasegawa (5)

I.S. Lowry proposed a model for land use in *A Model of Metropolis* in 1964 in a closed metropolis with a static model. This report deals with a modification of the Lowry model to construct a dynamic modeling system by utilizing system dynamics and an estimation of the future population distribution in the southern part of the Shiga prefecture with consideration of future developments of transportation in the area.

A5: Decisionmaking of Energy Supply Systems for Osaka City--Y. Suzuki (20), P.S. Pak (22), K. Ito (3)

The objective is to seek the optimal energy supply pattern of a metropolitan area under the multiobjective criterion function. Each type of energy (electricity, city gas, light and heavy oils, and coal) differs in cost, pollution load, energy efficiency, safety, and so forth. To forecast the coming 20 years energy demand in a region, alternative decisionmaking strategies for energy supply systems will need to be investigated taking into account demand-supply relationships, environmental constraints, energy costs, etc. This task is now going on under contract with the local government of Osaka City in the Kinki Region.

A6: Analysis of Industrial Locations by Using Mesh Data--Y. Suzuki (20), K. Shoji (22), T. Tsuji (24), S. Fujii (26), T. Katayama (9)

Much attention has been paid recently to the use of mesh data for analyzing various problems associated with regional and/or city planning. Mesh data is micro-level statistics on population, the number of manufacturers of a specific class, etc. Osaka City has produced mesh data (500m × 500m square mesh) based on the National Census and various statistics on industrial activity.

One of the on-going projects at Kansai Institute of Information Systems deals with the problem of relocating industries in Osaka City, and has decided to use the available mesh data to identify cause-effect relations relevant to the industrial location. The first step was to produce mesh maps in which the original data are transformed into a number of ranks according to an appropriate rule, and each mesh is given a rank label. Areal characteristics can be extracted by the mesh map, but its usefulness depends on the choice of ranking rule. Several ranking procedures have been devised and examined. Also the change in the values of a specific term can provide much information when the mesh data for two different years are available. Local smoothing of the original data has been found to be effective in removing the local moves due to construction of new buildings, road, etc. Potentials and correlations can also be calculated. The second step will be to identify possible cause-effect relations by making use of the mesh map and other information extracted from the original mesh data. These relations will be used to construct a state model which describes the transition of the industrial location. Once a state model is established, it can be used as a lower level sectional model in IRD planning.

A7: Estimation of Demand for the Urban Expressway System of the Hanshin Expressway Public Corporation Using System Dynamics--T. Hasegawa (5), T. Sasaki (7)

Estimation of demand for a toll road is very important not only in the planning stage but also in the operating stage. In the operating stage, the estimation should be accurate for good decisionmaking for operating and planning the system. There have been various methodologies for this type of estimation, but, as almost all of them are based on time series analyses they have been inadequate in following the large fluctuations in our society in recent days. This deals with a system dynamics model of the decisionmaking process for the estimation of users of the urban expressway and shows the results of simulation runs for the Hanshin Expressway with DYNAMO II. The simulation runs are for each month starting from the beginning of operation of the Hanshin Expressway and projected forwards for 20 years. The model is constructed to reproduce the number of users until March 1975 and shows an underestimate of about 6 percent. Future growth in the number of users is estimated under several conditions, such as with different GNP growth and different tolls.

A8: Risk Assessment in Regional and Urban Planning--K. Inoue (8)

Modern society has been more and more sensitive to natural and man-made hazards. To assess the risks of these hazards to the modern society and its environment is, thus, vital in regional and urban planning.

The objectives of the research are to develop methodologies to analyze the cause-consequence relation of a hazard, to develop methodologies to assess the overall risk of hazard, and to apply these methodologies to regional and urban planning through a case study in the Kinki Region.

B1: Studies on Environmental-Socioeconomic Effects of Industrial Development in the Kinki Region--H. Onoe (14), F. Seo (15), K. Nakagami (16), T. Nakatani (17), T. Sueishi (21), H. Horiyama (28)

The objective is to investigate the characteristics of recent industrial development and technological progress in various fields, and evaluate its environmental as well as socioeconomic effect on the Kinki area. Especially, our studies will be on prediction and evaluation of negative effects of the development on social welfare in rural and urban areas. Many problems, such as air and water pollution in industrial and residential areas, environmental destruction in fishing banks, energy problems in regional development, deficiency of water resources for multiobjective use, needs for circulation (reuse) of water resources, financial and legal problems in environmental protection, re-evaluation of concentrated as well as dispersed industrial location, and desirable change of industrial structure will be included in our project. Our methods have interdisciplinary characteristics and are based mainly on multiobjective, multilevel systems analysis, systems dynamics, and empirical application of decision analysis to environmental assessment. We intend to coordinate the results of our research into structural regional plans that are more reasonable than ones we have had so far. The ultimate aim of our project is to propose a newly integrated, regional economic policy based on environmental considerations.

B2: A Dynamic Model for Water Resources Management in the Yodo River Basin--N. Adachi (11), H. Tokumaru (5)

The future developments in the Kinki Region are suppose to be much restricted by available water resources. The Yodo River is of great importance because it supplies city water to 10 million people and industrial water to one of the economic centers in Japan. The Yodo River has as its source Lake Biwa, the largest lake in Japan. The large cities such as Osaka and Kyoto or the industries in these regions have been developed on the basis of the abundant water resources in the Yodo River basin. But, the rapid growth of the water demand and the worsening of water quality in the Yodo River and Lake Biwa are now causing serious problems. The study aims to construct a system model in order to manage and develop water resources in the Yodo River basin, from the point of view of both the quantity and quality. Of course, water quality is closely related to the amount of water flowing through the river. The model will consist of the following three submodels.

Water Quality Model

Assuming the present amounts of waste loads in the lake and the Yodo River, water quality will be simulated with this model. The water quality of Lake Biwa is evaluated with a dynamic model of the nutrient cycles in the lake. The Yodo River is divided into several reaches and the model constructed on the basis of mass balance equations of pollution materials.

Water Quantity Model

The quantity of water through the river can be controlled by the outflow rate from Lake Biwa and those of several reservoirs at the branches of the river. The amount of water flowing through the river will be estimated under various control schemes.

Planning Model for Waste Water Treatment Plants

Existing waste water treatment plants will not be enough to meet increasing pollution loads. Additional facilities have to be constructed in order to hold the water quality to certain standards. The scales, locations, and the order of construction of the plants has to be determined. The effects of constructing new plants or expansion of existing ones on water quality will be evaluated, and optimal policy will be searched under various restrictions.

B3: Multicriterion Decisionmaking in an Environmental Management System--H. Nakayama (26), Y. Sawaragi (1)

Recently, the influence of human activities on quality of the environment has been considered synthetically to decide a long-range and drastic policy for environmental problems. In many cases, there is not a single scale on which to measure the quality of the environment, and many criteria are introduced to attain the final goal--hence, the problem of multicriterion decisionmaking. In this work, we solve a water resource problem of the Kinki area. First, the hierarchical structure of objectives is specified with the help of interpretive structural modeling (ISM) suggested by the Battelle Institute. Second, each human activity is assessed by several criteria. Finally, the best policy is decided by a new type of interactive method recently developed. This method requests the decisionmaker to judge only whether his marginal rate of substitution of each criterion is more or less than the trade-off ratio, and therefore it seems especially valid for complex systems.

B4: Multiobjective Optimization in Water Resource Problems of the Yodo River Basin--M. Sakawa (27), Y. Sawaragi (1)

Lake Biwa and the Yodo River basin supplies drinking water to 10 million people and industrial water to the economic center of mid-Japan. Water resource/water pollution problems of the Yodo River basin result in serious environmental problems. We first formulate multiobjective optimization problems in water resource models of the Yodo River basin with several assumptions and simplifications and resolve the conflicts between development and protection, between upper and lower regions by applying the Surrogate Worth Trade-Off (SWT) method. In order to adjust them to reality, we then try to develop the effective and practical methodologies for modeling and decisionmaking of integrated regional environmental management.

Two Possible Research Fields for IRD Studies

Lennart Ohlsson

THE IRD BACKGROUND

IIASA has defined its research Programs to cover two classes of international problems--global and universal. IRD studies, in contrast to the Programs, is supposed to contain studies only of possible universal problems connected with the regional development of nations. These problems are defined so broadly that they include four basic research Areas, Resources and Environment, Human Settlements and Services, Management and Technology, and System and Decision Sciences.

While the coverage of research Areas is sufficiently broad to include analysis of interregional dependencies, the very exclusion of global problems from the IRD studies appears to exclude some of the most important of those dependencies from the point of view of effects on regional development. In my proposals, I have therefore chosen to disregard this exclusion of possible topics. I have interpreted the concept integrated regional development (IRD) as including aspects of both intraregional and interregional integration. The latter notion involes intricate problems of interregional division of labor that go right to the heart of the equity issue brought up by Professor Artle. In other words, it necessitates making explicit the fundamental choice of regional specialization.

Apart from Professor Artle's introductory paper, most of the discussion focused on methodological issues or the study of large scale projects. It seems to me that this is to start setting up a research program from the wrong end. A multidisciplinary research program in particular demands the definition of unifying research problems. It is exactly from this point of view that I have chosen to propose two broad research fields, within which one might pick macro-oriented research projects or micro-oriented ones suited for systems analytical approaches. This is very much the way in which the research programs of the Swedish Expert Group on Regional Studies (ERU) has been set up. With almost 12 years of organizing and initiating regional research on a multidisciplinary basis, the ERU committee may be looked upon as a national, small-scale predecessor of IRD studies at IIASA.

SOME LESSONS FROM PAST REGIONAL DEVELOPMENT

Some of the most influential determinants of regional development during the last hundred years or so have been those affecting the degree of regional autonomy or dependence. Despite world wars and depressions, industrialization has brought dramatic increases in interregional dependence in two ways. First, the long-term decrease in regional and national policy-imposed barriers to trade and the accompanying technological improvements in communication have meant a secular increase in gross trade ratios of almost each production stage at the regional or national level. This appears to be true for primary as well as secondary sectors. Secondly, the increased consumption and production per capita have brought about a shift towards consumption of products that are more easily tradable over long distances. In combination these two factors have acted to increase interregional and international dependencies, with widespread economic as well as social implications.

The post-World War II phenomenon of a further shift in composition towards the tertiary, service-producing sector seems to have been the prime counteracting force to increasing international dependence. Consequently, it has tended to preserve national autonomy in a pure economic sense. In contrast, its consequences for regional development have not unanimously tended to increase or even preserve regional autonomy. At least in Sweden, the regional development of the service sector of the 1960s appears to have strengthened the growth of the large cities especially. Regional development of the 1970s worked in the opposite direction. Hence, the future development of the service sector with respect to both the relative growth of components with different geographical tradability and the spatial organization of production seems to be one of the most important factors for future regional development with respect to human settlement patterns.

THE TWO PROPOSALS

The discussion so far has focused on whether the increased interregional and international integration of the commodity-producing sectors was counterbalanced by the increased role of services in the economy. Such a simplistically formulated question in net terms unfortunately tends to hide the vast regional consequences of the two underlying trends. As research fields they should therefore be separated in studies of the interregional development patterns while as micro-oriented studies of separate regions could cover both. Emphasizing the comparative nature of many IIASA projects, I have chosen to formulate two research fields:

- Comparative studies into the regional consequences of the economic and social integration of nations (or for large countries, regions);

- Comparative studies into the regional consequences of the service economy.

The first research field neatly covers aspects of the different interregional and international Availability of Resources and the Environment; Settlements of and Services for human beings; and Organization of the societies (Management and Technology). It can ideally be studied using methods from System and Decision Sciences. Moreover, although it is a global problem, it can be analyzed for separate regions as well as for the interregional development patterns of the nations included.

The second research field has a stronger emphasis on topics within the research Areas of Human Settlements and Services and Management and Technology. Since the member countries vary substantially with respect to the relative share of services in gross domestic product as well as possibly the organization--spatial and otherwise--of service production it might be fruitful to do comparative studies of the regional development of, for example, the medical care system of some other easily separated service sectors.

CURRENT SWEDISH RESEARCH TOPICS WITHIN THE TWO RESEARCH FIELDS

The following does not intend to give full coverage of Swedish research that can be classified within the two proposed research fields. Instead, I shall restrict myself to give one example from each field and two examples which combine aspects from both fields. All research topics have been taken from the current ERU research program.

"The international dependence and specialization trends of Swedish regions" is a research topic organized within the secretariat of ERU. Its purpose is to analyze and explain the comparative industrial specialization trends of eleven regions, trends which have been generated by major changes in Sweden's international specialization (partly as a result of policy changes), the regional human and nonhuman endowment of production resources, and Swedish regional policy. The study emphasizes the role of the nonraw material-based, nonsheltered industries in interregional comparisons of specialization patterns over a ten year period. Eighty out of 112 industries were classified in this category. The particular purpose of the study required a regionalization of the country in terms of parts homogeneous with respect to factor endowments, population densities, and regional policy incentives. Sweden was thus divided into 11 regions, which could be further subdivided into more than 30 subregions.

"Research into the role of the public sector in regional development processes." This is the name of the research program that includes as projects, studies in public decisionmaking and its regional consequences, the decisionmaking processes in order to analyze conflicts of interest in a spatial dimension, the economic consequences of public decisions, and the regional and local spin-off effects of public activities.

Two research projects cover various aspects of local and regional development. One aims at evaluating changes in the quality of life and human settlements in a southern region earlier specialized in the textile and cloth industry--an industry that, in the last 15 to 20 years, has suffered from cheaper imports from countries with wage levels of 10 to 50 percent those of Sweden. However, it was and still is, a fairly densely populated region with an expanding service production and potential for attracting other kinds of industrial production. The earlier autonomous local communities surrounding a textile plant have gradually turned into suburbs of larger cities with a commuting labor force. Such a change has deep-going consequences for the social networks and quality of life of the population.

Another research project is focused on the local development of a northern, extremely sparsely populated region that earlier specialized on the primary sector. It is the decline of the employment of this sector--following its increased interregional dependence--that caused severe employment problems and emigration to other regions. An input-output study of the region suggests very small intraregional linkages between industry and other sectors, despite the fact that the region itself is geographically isolated. Local labor market studies reveal the increasing role of public services as a source of employment.

CONCLUDING REMARKS

There are, of course, many other possible research topics. Some of the discussants at this meeting discussing somewhat different areas for research, have touched on possible issues that might be integrated under the two headings I have proposed, e.g. Professors Artle, Hamilton, and Stöhr.

As earlier emphasized, the two proposed research fields should be looked upon as broad analytical frameworks within which a rich variety of research projects can flourish. Hopefully, Swedish regional scientists will be able to cooperate within one or other field of the IRD studies, whatever the final choice will be.

A Few Remarks About Future IRD Activities

S.S. Shatalin

The difficulties posed by regional development studies are very great. It is difficult to formulate studies for IIASA although I think we have already made a few constructive suggestions and I think that there are objective reasons for studies to take place. What are the reasons?

First is the importance of the problem under discussion. The importance for my country is self-evident; and, moreover, Professor Albegov has already talked about the problems of regional development in the USSR even if mainly about modeling attempts to solve these problems. There are a number of different nonmodeling attempts to solve them.

Secondly, there is already a lot of experience accumulated all over the world (in methodology, practical applications, and other empirical studies) on regional development, and I think that, in spite of the fact that in almost every country there is a lot of research on regional development, the separate individual country cannot solve all the problems related to regional development. (I have in mind especially the theoretical and methodological problems of regional development.) All of us need international experience in regional development. Certainly all the problems mentioned here have their own specific aspects and are being solved in different ways in different countries, but I think, in spite of this, there are general approaches for their solution not dependent on individual countries or regions. There are national organizations in fact already cooperating with IIASA or ready to start collaboration on these regional development studies. All my colleagues have declared their readiness to start collaboration with the IIASA IRD studies. All the research of all the research institutes in my country would also be available to these IIASA studies.

It is important to define the final results of these regional studies at IIASA. These should be a certain methodology representing a system of models sufficiently universal that, in spite of the differences between various regions, will allow one to analyze the problems, maybe specific for these regions or nations. The construction of such a system of models should be a process of generalization from the experience accumulated in the world with respect to these models. It is dangerous for IIASA to try to construct a new, its own, system of models that differs from national experience. Certainly it should not be just a combination, or a mechanical complex of the models developed in different countries. Rather, it should be a system based on the models that will also be practical or give practical solutions--models that can provide useful information. We could certainly state more ambitious aims, and it would be very interesting as a theoretical speculation but it would not be able to provide practical instruments for decisionmaking. We have three years during which to obtain some practical instruments and techniques that will help decisionmakers--make things easier for them.

Before we construct these models, we have to answer some basic conceptual questions. We speak here about regional development but have not provided the definition of what a region is. This is not an academic problem, but an operational notion. It would be useful in spite of the differences between regions, to provide a sort of typical classification of regions, taking account of economic, political, and social factors.

There are also other important questions that should be answered before we start to construct a framework for study:

- What are the coordination mechanisms between national and regional goals?

- What are the mechanisms coordinating economic efficiency if we just consider the economic approach?

- How can we take into account the economic, ecological, and sociological consequences of any decision?

- How can we solve the problem of equity between the regions, and within the regions?

Equality of access within a region is a very interesting concept and ways should be found for its implementation. Some have mentioned that quality of life can be chosen as an objective function for a region--e.g. our Japanese colleagues and Professor Domanski. It is a fundamental problem that must be studied at IIASA. It is important not only for regional development, but also at the national level. Before the model construction stage, it would be valuable to elaborate this approach constructively and study it in more detail, in terms of both general and individual features. Since a system of models can serve as a basis for analyzing regional development, it should have a core directed at strategic problems of regional development. Input-output approaches, linear programming, and game theory can all be good techniques to use.

Along with this activity, a set of submodels, territorial models, could be constructed within various IIASA projects which would allow analysis of specific problems in more detail. I am not a specialist in mathematical modeling, but I think that the system of models must be flexible enough to provide various insights into any problem. It is difficult to believe that if the Soviet Union were to get this system of models from IIASA, it could apply them directly to solving its problems. But it would be very useful if some basic variant of them could be modified according to our particular problems. We could add some submodels, but still maintain the general approach. As far as I know, our French colleagues use a similar system of models and a similar core model in the development of their five-year national plans, which can be adjusted for various issues, or problems.

I think that currently at IIASA we have both researchers and research that will allow us to investigate such approaches; one necessary part of the IRD studies is a case study. It seems to me that the supply of such suggestions for case studies exceeds the demand. If I am right, this is good. But we should be careful in our choice of a case study, and I have only a few comments on this subject. We should investigate both planned and market economies but this difference is not enough in itself; the regions to be investigated should be different in some other aspects. For example, one region could be a well-developed one for investigating ecological, economic, and sociological problems, and the other a newly-developing region for studying harmonious growth, for example, and for testing the various methodological approaches. I know that there is an agreement between IIASA and Bulgaria on the Silistra region study. I liked the Japanese project very much but Japan is very far away and the experiment might cost IIASA too much; but in spite of the expense the region is a very interesting and promising one for IIASA exploration. The regions proposed by our Italian and Polish colleagues are also very interesting. It is not easy for me to estimate the suggestion of Professor Hamilton with respect to the Bratsk-Ilimsk complex as a case study but it seems to me that their experience of this problem can be used fruitfully in our regional development study.

Concepts and Methods of Regional Analysis--A Review

J.R. Millar

A PARADIGM OF POLICY RESEARCH

The most abstract conception of research activities in a policy environment requires the definition of only six classes of conceptual entities:

- Policy alternatives (also known in the literature, depending on author's disciplines, as policy options, system inputs, independent variables, etc.);
- Intermediary variables (also known as structural variables, leverage variables, system throughputs, etc.);
- Output variables (also known as objectives, valued outputs, target variables, goal indicators, impact variables, effect variables, dependent variables, system outputs, etc.);
- Values (also known as utilities, weights, government priorities, judgments, etc., depending on the perspectives of authors);
- Mapping functions (a) relating by logical, mathematical, or statistical means a specific variable in one of the above categories to a specific variable in another set;
- Mapping functions (b) relating variables to each other within one of the above sets.

These six categories of conceptual entities can be arranged in a sequence derived from an intuitive understanding of the social system and its change through time. Figure 1 depicts such a sequence. The chart indicates that policy alternatives are hypothetical interventions in the social system designed to alter its functioning and its rules. Their impact on the conditions of people (output variables) is largely understood through their consequences on intermediary variables that are more often than not the structural characteristics of the society. For instance, the distribution of income in society (one output variable from the viewpoint of individuals) is manipulated by (among other things) taxation policies, which determine to a large extent the reward structure (an intermediate and structural variable) of the society. Another pertinent example is the way in which policies

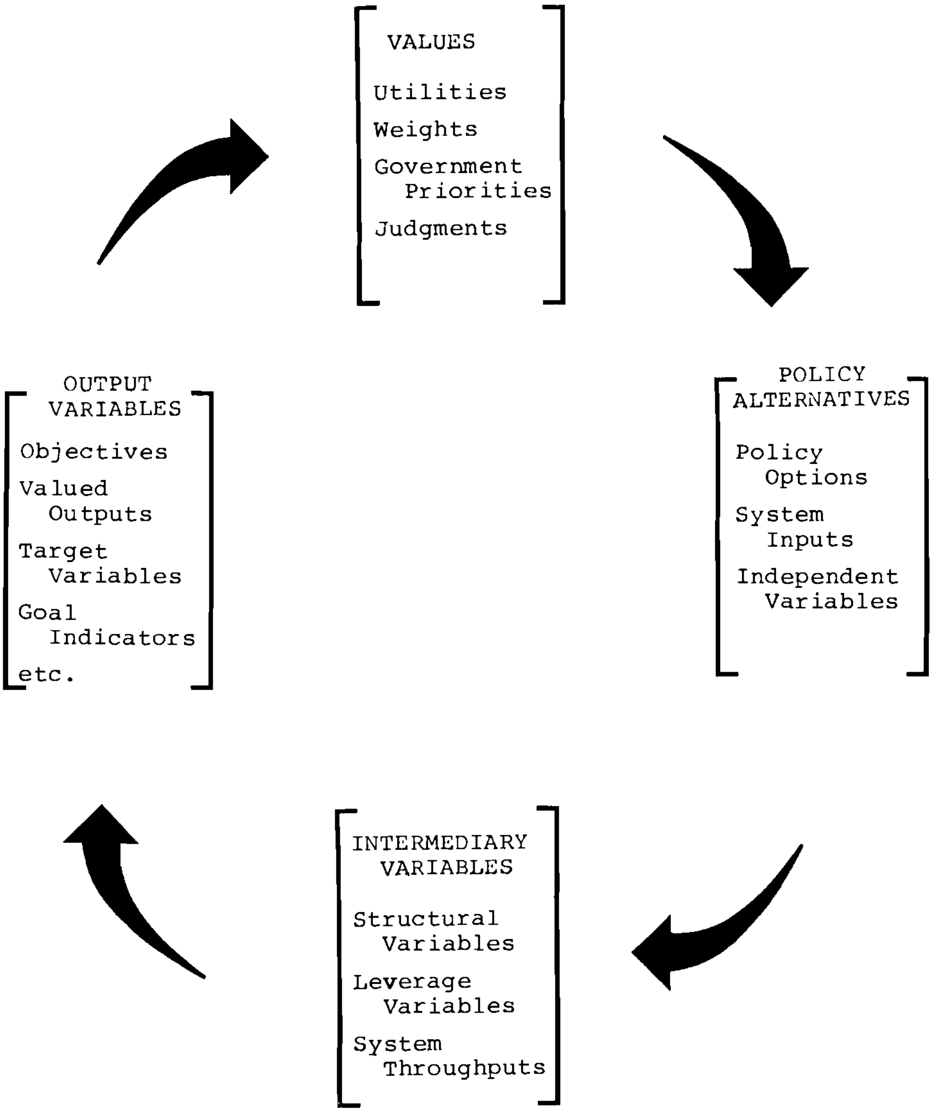

Figure 1. A general paradigm of policy research, showing the functional relations between its components.

on transportation (a series of structural, intermediate, and leverage variables) are designed to influence the location of industry and employment (output variables for individuals). Following the loop clockwise, we find the structural variables are the major determinants of individual actions and well-being, i.e. of the outputs of the social system for people. In turn people's perceptions of their conditions, well-being, and latitude for action determines the relative weights, utilities and values that form the input data to the major decisionmaking components of the system. Finally, it is seen in the Figure that policy alternatives are in relation to these values, and, in fact, derived from them.

In summary, Figure 1 indicates that policy changes (as inputs) are possible in any given system, and that they can be formulated in such outputs. Structures and outputs are themselves interrelated by deterministic* chains. On the basis of new circumstances produced by such outputs, policy options can be assessed again, negotiated and modified after considerable refocusing of issues among population segments, in order to keep the system capable of sustaining high quality of life for its members. The nature of feedback in the political process is implied by such reassessment.

The major advantages of a general paradigm as shown in Figure 1 is that it reminds us of the categories of variables and relationships that must be substantially specified for particular analysis, and that it shows these variables to be directly or indirectly related in a circular feedback system. It does not provide the specific nature of the substantive variables, nor the closeness of their deterministic links. But it does give us their taxonomy and a fixed point or reference for the discussion of their general characteristics.**

The complete conceptual domain of policy research is the (infinite) set of all possible sequential combinations of these elements. Any specific research involves discovering, quantifying, or otherwise explicating given elements of one or more sets that have correspondence to given elements in other sets--e.g., to discover the relationship between a range of policy alternatives and a specified set of output indicators. Or, given a set of relations known to be to some extent representative of reality,

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*The term deterministic is used here as a broad category of relations including probabilistic ones, "determining the boundaries of", causal relations, etc.

**The paradigm, in its simplicity and great level of abstraction, also tends to obscure some rather important characteristics of the phenomena of concern. Some examples of complicating factors are: (a) structural change and individual actions are in a state of resonance--thus the arrow connecting intermediary to output variables is not strictly uni-directional; (b) all to discover the policy alternative that best achieves a specified set of goals. In the next section a sample of policy analysis endeavors is examined by way of illustration from the perspective offered by the paradigm.

A CLASSIFICATION OF PROJECTS AND THEIR COMPONENTS

Paradigms cannot be tested, but are useful insofar as they provide a new or innovative perspective on other phenomena. What follows in this section, therefore, may not be considered an empirical test of the preceding section, but rather an illustration of how it might be used to classify the components in a policy research work program. The output generated by 20 analysts (Policy Analysis Division and Economic Development Analysis Division), over a sample period extending from June to December 1976, has been classified according to the emphasis given to the concepts outlined, yielding some interesting observations.*

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four categories of concepts are constrained by exogenous data, e.g. by policies, structures, outputs, and values of neighboring systems (i.e. other countries); (c) the functional relations between categories are mutable and tend to be themselves functions of levels attained by certain variables--e.g., the proportion of money saved is related functionally to changes of income, but by a function that changes through time according to many economic variables including levels of income; (d) each social system is nested within larger ones and/or is composed of nested systems so that at each system level policies, structures, outputs, and values are to greater or lesser extents determined or constrained by variables at other system levels; (e) each variable change is constrained by the level attained in the variable at previous points in time; (f) similarly, each variable in the system is evolving through time as a function of previous policy interventions and other events, representing, as it were, a moving target; (g) researching and gaining knowledge of one set of relations is in itself an intervention leading to changes of perceptions and values.

*This classification is approximate in three senses. First, all analytical projects contain some discussion of peripheral issues. A project designed to investigate relations between transportation changes and output indicators will undoubtedly address policy concerns. Even if it does not do so explicitly, in all probability it was designed to do so, and therefore implied some initial work in that area. Second, while the project may have the study of relations as its principal aim, depending on the availability of data, more work could have been expended in the quantification of concepts than in researching their connectedness. Third, the survey reported here includes analysts, mentioning nothing of support staff, and is therefore only a very crude indicator of resources expended.

As can be seen in Figure 2 nearly 95 percent of the analysis has focused on policies, the impact of policies on socioeconomic structural variables, and their impact on output variables. This observation points to the fact that our research is not questioning broader statements of objectives on which all policies are founded. This is not altogether unexpected since we normally assume the translation (or aggregation) of "level of living" and "quality of life" variables (and their associated personal values) into political statements of social values and government objectives to be properly the domain of politicians and the subject of study of their personal advisors.

Following the chart in Figure 2 clockwise we find 5 percent of analytical resources were expended in the examination of relations between sociopolitical values and policy alternatives. Questions asked in this domain may flow in either direction: Which policy alternatives should be pursued given a new priority ranking (or, a new understanding) of political values? Or, given the suggestion of a new policy initiative, find its relationships to stated government objectives. Table 1 is but one example of this type of work; it is instructive to note that not much accepted methodology exists at this level of discourse beyond standard taxonomical and classificatory devices. One attempt to introduce quantitative techniques in this important link is presented in the next section dealing with project CANGO.

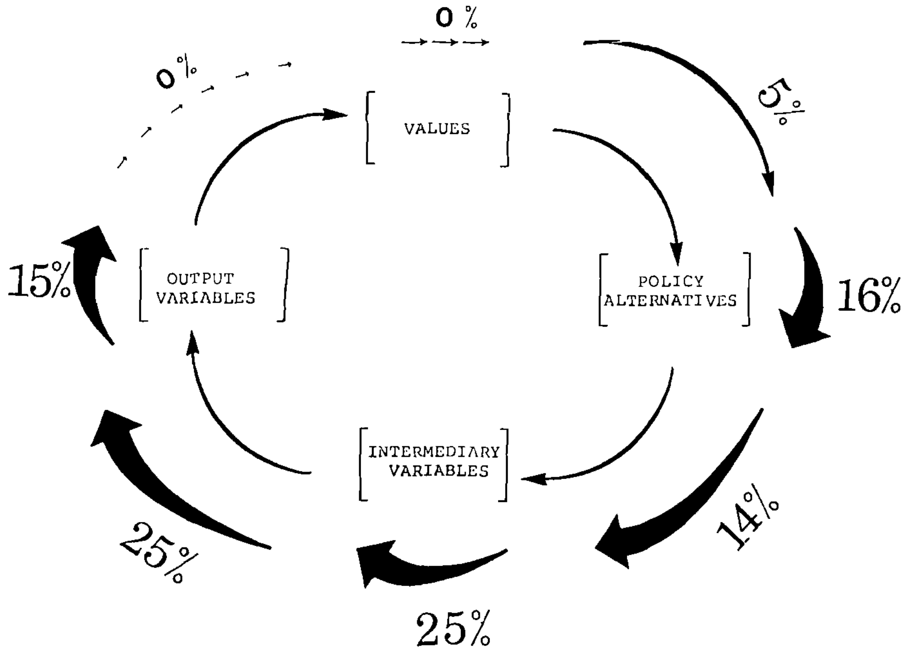

Figure 2. Approximate expenditures of staff resources in different modes of policy research.

Table 1. How "regional development" fits into the context of total government activity.

Policy Area	Government Activity	Examples of Program Outputs	Departments Responsible
ECONOMIC DEVELOPMENT	INDUSTRIAL DEVELOPMENT	Actual production of marketable goods and services	DREE ITC
	RESOURCE MANAGEMENT	Research, surveying, control, resource renewal	DREE DOE EMR AGR.
SOCIAL DEVELOPMENT	INFRASTRUCTURE (INDUSTRIAL AND/OR SOCIAL)	Industrial parks, electricity, oil, gas, transportation & communications, sewer & water, housing, educational, medical, recreation facilities	DREE MOT CMHC EMR
	HUMAN CAPITAL	Education, occupational training	M&I
SOCIAL WELFARE	SOCIAL SERVICES	Medical, counseling, mobility, housing assistance	NH&W CMHC M&I
	INCOME TRANSFERS	Cheques, direct employment	M&I UIC NH&W
OTHER GOVERNMENT ACTIVITY	LOCAL SERVICES	Mail, police, fire, recreation, etc., local inputs to national services	CPO RCMP DND
	NATIONAL SERVICES	Defense, justice, prisons, culture, market regulation, basic research, etc.	DND JUSTICE SEC.ST. COM. CCA

DREE programming 1976

1969

"regional development"

regional impact and therefore DREE policy interest

Moving along the chart in Figure 2, we find 16 percent of staff resources have been involved in the study and elaboration of policies, another 14 percent in the study of their implications for socioeconomic structural variables. It is in these two categories that we may list the widest diversity of projects; to name some examples:

- Locational choices and their community impacts,
- Sectoral policies and their distributional effects,
- Industrial structure impact of present DREE initiatives (retrospective),
- Projected impacts of proposed policy alternatives (prospective),
- Employment generation requirements and proposed measures, and so forth.

We now look further in Figure 2 to the analysis of intermediary and output variables and their relationships. This type of study is generally a quantitative exercise, best fits the stereotype of simulation models in policy research, and generally assumes the presence of analytical tools developed for this purpose (theory, data, and software)--i.e. econometric models (CANDIDE-R), input-output models, community structure models, and the like. Such research tools, of course, are developed in the study of socioeconomic structural and output variables that, as the chart indicates, have involved 65 percent of analytical resources during the sample period. This distinction is useful to make, for it indicates that much basic analytical work is required in order to address policy-impact issues meaningfully.* Some examples of current activities in these categories are outlined later and an attempt is made to derive some general propositions regarding their characteristics.

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*The ratio 65/30, or roughly 2 to 1, between basic analysis and policy-impact analysis is similar to the ratio that has been maintained through the last several years. The main reasons why a policy analysis group is incapable of by-passing basic research may be postulated to be: (a) Theory developed elsewhere is based on concepts too abstract to be of direct relevance to policy-impact evaluation. (b) Available theory is too general for the same purposes; its tenets often require translation to higher specificity. (c) Research conducted elsewhere is frequently based on small samples; policy-impact analysis requires replication with larger data sets (often complete national data sets). (d) Available research is often based on obsolete data; replication is required utilizing latest available data files.

AN EXPERIMENT IN THE QUANTIFICATION OF VALUES: CANGO*

The essence of many decisionmaking situations is that they require the simultaneous achievement of a set of objectives that are often noncommensurate and between which trade-offs cannot be specified. Two approaches can be utilized in such circumstances: optimizing and satisfying.

There are several major problems inherent in the application of optimizing techniques in multiobjective situations. First, they assume that theories of impact of public policy on society can be well specified. While in fact, only very partial theories exist. Second, they generally involve attempts on the part of analysts to convert noncommensurate observations to uni-dimensional scales or common denominators. Such manipulations are based on implicit value judgments (often with no consensus) and, in addition, their aggregation fails to note the major trade-offs between them. This is equivalent to ignoring the essence of the problem, as the multiple objectives are reduced to one. Third, in practice, the calculations performed are usually so elaborate as to preclude the possibility of decisionmakers disentangling implicit value judgments to replace them with their own.

In contrast, the satisfying approach usually requires the specification of an explicit set of value judgments. Provided the model utilized is not excessively complex from a technical point of view, this provides decisionmakers with the ability to modify these value judgments in conformity with their own. CANGO is a model for decisionmaking in locational choice problems; it differs from most analytical activities in that it utilized the mix of value judgments as the primary variable input data; its output is a rank-ordering of locations (or matching of locations) accompanied by a score for each location determined by the extent to which all given objectives can or cannot be satisfied by the choice of that location. Looking back at Figure 1, we can place CANGO in the upper-right quadrant--the questions it addresses are: What policy is to be followed to best satisfy a weighted set of objectives? And, as we change the weights given to different objectives, how is the solution of the location problem affected? A quantitative model in the upper-right quadrant represents such an unusual departure in the current decisionmaking environment as to require further explanation.

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*Much of the thought behind this section was developed by Sergio Sismondo, Richard Zuker, Elizabeth Harman, Carl Taylor, and Brian Near of the Analysis and Liaison Branch, DREE.

CANGO is an acronym for five concepts which played a major role in the original project for which the tool was developed: Capacity to grow, Attractiveness, Need, Government designation, and Opportunity.

The CANGO model consists of the following five elements.

Alternatives

This is the set of locations under consideration.

Attributes

The characteristics that describe the alternatives that make up the set of locations and on which the selection will be based. Attributes are defined in two stages:

Criteria Sets

Such theory as may exist to approach the problem is made explicit by the identification of nodal concepts, which we refer to here as criteria sets, which define the relation between objectives and characteristics of locations.

Variables

For each of the above concepts a series of variables can be identified for their measurement (the key role of theory is to relate these measurements to variables and criteria sets. For each alternative location these data will be known, and will constitute the data matrix for the locational choice problem.

Thresholds

Locations are ordered along each variable within criteria sets in the direction that fulfills the meaning of the concept being measured. For each variable, two thresholds or cutoffs are specified dividing the range of the variable into three regions. The region "above" the upper threshold is the area of "preference" on the variable, the region between the thresholds is the area of "indifference" and the region "below" the lower threshold is the area of "rejection".

Weights

These are measures of the relative importance of the criteria sets and variables. The weights are assigned in a two-step process--first, to criteria sets and then to variables within criteria sets.

<u>Solution Algorithm</u>

The solution algorithm is a procedure that ranks the alternatives in order of preference based upon the variables selected and the weights and thresholds chosen.

A solution is a rank ordered set of locations and is derived in the following way:

- All locations that satisfy the conditions above the upper thresholds for all variables are tested. These are the preferred locations in the solution since no requirement has been violated and the locations have all the characteristics demanded.

- If no solution exists, i.e. there is no location above all upper thresholds, then a systematic search is carried out to find a solution on the basis of the relaxation of certain constraints or requirements starting with the least important. It is during this process that the user comes to appreciate the effects that value judgments have on the outcome.

A full description of the algorithm is perhaps unnecessary at this stage but can be made available. What the algorithm produces is an ordered ranking of locations each accompanied by a score that indicates the extent to which each location satisfies the weighted conditions given.

The system can be seen to operate like a series of sieves through which locations pass on the basis of their characteristics and the technical specifications of the sieves. Most successful locations are those that satisfy all requirements specified.

We have gone through some effort to describe this particular methodology because, as we said, it represents a significant departure from quantitative techniques commonly utilized in policy analysis. Since DREE, as well as others have found the technique to be useful in an increasing variety of problem situations, it is necessary to outline its advantages and, as far as possible, identify its weaknesses.

From a technical perspective the main advantage offered by CANGO is the provision of a framework for the selection and organization of disparate and very large data sets (consisting, depending on the problem, of as many as 50 variables over more than 1000 communities in Canada). It can be easily seen that bringing this information to bear on a problem of selection of, say, 20 preferred locations is a formidable task indeed. In the decisionmaking context the method brings much that is new and refreshing. (a) CANGO permits the decisionmaker to render his value judgments explicit through weighting of criteria sets and variables, and through the setting of thresholds. It does so in interaction with a computing device, producing immediate feedback to the policymaker regarding the consequences of his judgments; iteration and experimentation are therefore possible and tempting. (b) A framework is provided for the reconciliation of conflicting objectives. The system has the capacity to present alternative solutions on the basis of the satisfaction of a series of single objectives that can be compared with each other, and the satisfaction of equally weighted or differentially weighted objectives. The trade-offs among objectives are represented. (c) Concerns that are not easily quantified can be introduced into the system. And (d), perhaps most important, the system provides a focus for discussion and compromise among policymakers in the process of choosing and setting weights and thresholds and observing the outputs generated by their preferences.

The disadvantages we have been able to identify in the operation of the system lie mainly in its possible misapplications. No matter how carefully criteria sets and variables may be initially chosen by means of theoretical discussion and empirical observation, it is always possible for the user of the model to exclude variables at will by simply attaching a weight of zero to them.* Other analogous manipulations, equally anti-theoretical, might be to include variables whimsically, to raise or lower thresholds so they are no longer discriminatory, or to set high weights and low weights on bases other than true judgment of their significance.

CANGO has opened the door to further use of systematic decision models. It has shown that some receptivity exists in the government for improved methodologies to deal with that upper-right quadrant. In addition to the advantages already mentioned, and at a very general level, we may conclude that: in the context of regional planning and development, systematic methodologies for dealing with the upper-right quadrant of Figure 1 are urgently needed; policy research models that closely approximate value issues and can properly address mutually conflicting objectives, are of prime importance to an activity field plagued by internal riddles as is the case of regional planning and programming; and that much more work is required in the development of such methods.

Let us now turn to examples of analytical activities pertaining to the lower half of the Figure, i.e. relating policies, structures and outcomes. In the last section of this paper we will return to speculate on further implications of the upper half of Figure 1.

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*This is a controversial point; we may believe in "user sovereignty", in which case there is no misapplication of what is essentially an "idiot-box"; on the other hand a human proclivity to interpret hard-copy results as meaningful regardless of initial assumptions exists, leading us to a warning regarding misrepresentation of findings.

POLICY IMPACT STUDIES

If the upper portion of Figure 1 is the Cinderella of policy analysis, the lower portion is its pampered child.

The diversity and scope of work undertaken in this domain offers a rich experience to be examined. Among the most interesting cases we can discuss the construction of an interprovincial input-output table, a model designed to test the credibility and consistency of predictions and projections regarding Canada's regional futures, and the development of community structure research as it applies to regional problems. A classification of recent and current analysis activities shows these topics represent three categories from among 17, leaving, therefore, 14 other avenues of work unmentioned in this paper--the choice was rather arbitrary.

The construction of an interprovincial input-output model is perhaps the most orthodox of the three examples and it is mentioned briefly here at least partially for that reason. The rationale for embarking on such a massive effort as the construction of income and employment input-output matrices for each of ten provinces and for their interactions is simple: a simulation tool is required that will permit computation of income and employment impacts of suggested policy alternatives taking into account leakages between provinces. Clearly, this is a useful tool that can aid in the evaluation of policies for regional development planning.

The reasons why such a model did not exist elsewhere are less clear. Although some previous attempts were made, they were rather inadequate. Not because theory is lacking, for a static input-output theory is well developed elsewhere, but largely on account of data limitations. The problem tackled here was to modify methodologies for construction of the tables in order to maximize the use of available data, given also its nonoptimal form, to allow for potential applications of interest to regional development planning. Major analytical effort was expended in obtaining a parsimonious but useful level of disaggregation, and some innovation was required in the software. In theoretical terms, however, the input-output effort does not significantly add to knowledge. In this sense, it is a good example of the routine analyses that have characterized government work on the bottom half of Figure 1. Precision, completeness, validity, and methodological innovation are at a premium; conceptual breakthroughs are few and far between.

The second analytical project mentioned is considerably less elaborate than input-output tables insofar as it is more aggregated, involves less precision, less computation, and in general makes lesser pretenses of accurate forecasting. It is nevertheless novel and interesting in its conception--less orthodox, as it were. The project is named "Regional Futures" and deals with the interactions of 96 data series projected 25 years in the future for each one of four Canadian regions and their sum. Unlike most projections, this one does not pretend to discover one scenario that is more likely to come to pass than any other. Regional Futures is designed to uncover the implications for 95 important data series when the 96th is altered at will, no matter how unfounded the assumption might be. (More than one input series may be manipulated at the same time provided consistency checks are made.) This is an unusual model: while most models are like boxes where one side is clearly labeled "inputs" and the opposite one labeled "outputs"; this one is more like a 96 faced polyhedron where the analyst chooses at will any one face to label "inputs", turning all others into "outputs". Regional Futures is more like a ball than like a box. The model is designed to answer questions of the general type: If variable X is to attain the value x_{ij} in region i and year j what must happen, to be consistent, in all regions for all other variables?

This model, like CANGO, is so unusual as to require some further explanation. Demographic and economic variables are projected within an accounting framework that render them all compatible. The structure of the model is, in fact, a series of identities and numerous consistency checks. The initial input data consists of best guesses of the following principal variables: base population (by age, sex, and province), death rates, fertility rates, immigration, provincial distribution of net immigration, labor force projections, participation rates, unemployment rates, sector shares of employment, productivity by sector, and regional share of output by sector. All other variables are derived by following the accounting relationships. This initial set of mutually consistent time series constitutes a "base case", not because it has any particular merit as a best guess, but because such a foundation is necessary to examine later the sensitivity of the projections as one or more variables are manipulated.

For the purpose of illustration, one assumption fed into the model was that each region would re-obtain a population share equivalent to the 1971 distribution, by the year 2001--not a far-fetched proposition at first sight. The algorithm computes that, other things being equal, in order to maintain constant unemployment rates at current levels, such a population distribution would require, in addition to expected employment generation in each region, the generation of a number of jobs equivalent to the total relocation of every employment opportunity in Toronto to the slow growth areas. In order of magnitude, this figure is almost equal to the number of jobs currently existing in the entire Atlantic Region.

One cannot help but notice the similarities between Regional Futures and CANGO. Although they clearly belong to different quadrants of the paradigm (Regional Futures being on the lower-left), the two methods make no pretense of being able to produce a "best answer" because they recognize only the interdependence of phenomena, leaving to others the identification of values and objectives associated with the phenomena. On the other hand, both models provide the policymaker with reasonably rigorous frameworks within which, in the case of CANGO, value assumptions can be discussed, and in the case of Regional Futures, the interdependencies can be understood.

A third example is the development of community analysis techniques that can be traced through a stream of projects rather than be labeled a single project. The challenge is to provide a framework for the discussion of community impacts of significant resource, transportation, industrial, tariff, or taxation policy proposals. Without repeating the stream of projects that led to each and every measurement in the community analysis (CANGO was one), let us look at some of the currently utilized instruments.

First is the identification of 1061 nodes (more or less urban), each one with a rural hinterland, which approximately covers the map of Canada (90 percent population coverage). This information is correlated with major geographic referencing systems used in the Government: census code, SGC code, and postal code. These constitute the disaggregate community units of analysis; aggregation upwards is routinely performed. Second, the road distance connecting all these nodes is machine readable accompanied by appropriate software. This provides answers to questions of the type: Given loss of employment in one industry in one community, what are comparable opportunities within distance X? Or, what is the differential juvenile crime rate as a function of distance to the higher education infrastructure? Third, hundreds of infrastructure-related variables and indicators are on file for each node, and many also for each rural fringe. Fourth, quality of life indicators (system output variables) derived by various scaling techniques, have been computed for each node and their aggregations.* Fifth, are a number of devices for the measurement of community structure concepts. Among them we can make special note of Guttman Scales. These have been used, for example, to measure the extent of differentiation of cultural facilities in communities, and similar scales have been constructed for virtually all institutional sectors including the private tertiary complex.** The scale rank orders all communities and all items of cultural facilities, showing the statistical regularity with which they occur. This results in the familiar step-function relating the scale value and the number of communities in the same rank. If X's indicate the presence of an item in a community,

*See: Taylor, C., *Social Conditions Report (SCORE)*, 1975. Report available through DREE, Public Information Division.

**Primary and most secondary industries cannot be treated in this fashion, however, because their location depends on factors other than settlement pattern.

Table 2 illustrates graphically a number of hypotheses which can tentatively be drawn from such scales:*

Table 2. Statistics and partial display of a Guttman Scale of cultural infrastructure in 791 Canadian communities.

IDENTER	SCALE	3	1	2	7	8	10	11	5	4	9	6
40012	11	X	X	X	X	X	X	X	X	X	X	X
40020	11	X	X	X	X	.	X	.	X	X	X	X
60010	11	X	X	X	X	X	X	X	X	X	X	X
80010	11	X	X	X	X	X	X	X	.	X	X	X
00010	10	X	X	X	X	X	.	.	X	X	X	.
20010	10	X	X	X	X	X	.	.	X	X	X	.
50010	10	X	X	X	X	X	X	X	X	X	X	.
50032	10	X	X	X	X	X	X	X	X	X	X	.
50141	10	X	X	X	X	X	.	X	X	X	X	.
70010	10	X	X	X	X	X	.	X	.	X	X	.
70020	10	X	X	X	X	X	X	X	.	X	X	.
80020	10	X	X	X	.	X	X	.	X	X	X	.
90010	10	X	X	X	X	X	X	.	X	X	X	.
90020	10	X	X	X	X	X	X	.	X	X	X	.
50020	9	X	X	X	X	X	X	X	.	X	.	.
50072	9	X	X	X	X	X	X	.	X	X	.	.
50130	9	X	X	X	X	X	.	X	.	X	.	.
30031	8	X	X	X	X	X	X	X	X	.	.	.
50341	8	X	X	X	X	.	X	.	X	.	.	X
70252	8	X	X	X	X	.	.	X	X	.	.	.
30072	7	X	X	X	.	X	.	X	.	.	.	.
50101	7	X	X	X	X	X	.	X	.	.	.	.
50110	7	X	X	X	X	.	X	X	.	.	.	.
50182	7	X	X	X	X	.	X	X	.	.	.	.
70042	7	X	X	X	.	X	X	X	.	.	.	.
70072	7	X	X	X	.	X	.	X	.	.	.	.
80052	7	X	X	X	X	X	X	X	.	.	.	.
90162	7	X	X	X	X	X	X	X	.	.	.	.
40222	6	X	X	X	.	X	X	.	.	.	.	.
42553	6	X	.	X	X	.	X	.	.	.	.	.
50532	6	X	.	X	.	X	X	.	.	.	.	.
50642	6	X	X	X	X	X	X	.	.	.	.	.
50783	6	X	X	X	X	.	X	.	.	.	.	.
70052	6	X	X	X	.	X	X	.	.	.	.	.
70332	6	X	X	X	.	X	X	.	.	.	.	.
80903	6	X	X	X	X	X	X	.	.	.	.	.
90041	6	X	X	X	X	.	X	.	.	.	.	.
00022	5	X	X	X	.	X	.	.	.	.	.	.
10011	5	X	X	X	X	X	.	.	.	.	.	.
20182	5	X	X	X	X	X	.	.	.	.	.	.
30021	5	X	X	X	X	X	.	.	.	X	.	.
30061	5	X	X	X	.	X	.	.	.	.	.	.
30162	5	X	X	X	.	X	.	.	.	.	.	.
30292	5	X	X	.	X	X	.	.	X	.	.	.
40061	5	X	X	X	X	X	.	.	.	X	.	.
40071	5	X	X	X	.	X	.	.	.	.	.	X
40052	5	X	X	X	.	X	.	.	.	.	.	.
40092	5	X	X	X	X	X	.	.	.	.	.	X
40122	5	X	X	X	.	X	.	.	.	.	.	.

*A remarkably high degree of unidimensionality occurs in this particular study of museum facilities in communities.

- Dots to the left of the line indicate gaps; should they be filled?

- Crosses to the right of the line indicate unusually advanced steps; are these to indicate potential for development? Will the remaining dots fill in?

- Is it akin to a balanced growth strategy to build the next item missing in a community?

- Is it akin to unbalanced strategies to build far to the right of the line and expect gaps to be filled? Does a concept of "backward institutional linkages" make sense?

- Tall rungs in the ladder indicate difficult thresholds to pass, should these be the target of subsidies? Would further steps be taken by communities that are aided to jump these thresholds?

It is not difficult to see from an intuitive viewpoint what the relevance of such instruments can be for planning developmental interventions. More difficult is to provide a sound theoretical base for the detailed interpretation of such results; conceptual advance are required in this area.

CONCLUSION

Recent literature on the subject of policy analysis has tended to emphasize the interrelation of everything with everything else and consequently has, in the large, proposed a wider utilization of systems analysis and macro-models to solve the "macro-problem". Much of this writing contends that without systematic understanding of all interrelated social-political-environmental factors, society cannot possibly be making optimal decisions.

Without disagreeing with this notion, this paper has proposed an approach to policy analysis in the regional development context that places at least as much emphasis on the analytic challenge implicit in relating to the decisionmaking system as is generally placed on developing an understanding of the system being affected. One can imagine the latter effort in rather grandiose terms.

Basically, what would be involved is the expansion and coordination of a type of modeling activity described in the previous section. We can estimate, for the sake of argument, that 50 scientific man-years of analytical work comparable to the above would produce an integrated socio-economic-environmental-regional model with some dynamic features built in. Its excellence, from a strictly technical point of view, would largely depend on the investment one were willing to make in data collection. Furthermore, the system could be such as to withstand refinement as new information became available.

Three fundamental and related problems can be foreseen: (a) the system would be static in its interpretation of the structural equations that relate variables to each other; the operator of the system would be like the driver of a giant machine, pulling levers and pushing buttons, trying to bring the machine under his comprehension and control, as the machine changes its pattern of response to the very stimuli which he offers; (b) the system would be unwielding in its complexity; lack of comprehension would rapidly lead to incredulity, and consequently to indifference; the policymaker would not risk his reputation by relying on masses of information that he could not disentangle; and (c) regardless of what precision could be built into the system, it would not *solve* policy problems, it would merely *illustrate* them. The matter of setting, evaluating, and compromising objectives would not be simplified; rather, it will have been complicated by introducing new interrelations and constraints (of empirical validity, to be sure, but of unclear significance to the horizons of political action). We do not wish to argue that such a proposition would not contain heuristic value--it certainly would. But its context is problematic; it may better belong to a decentralized and autonomous investigative institution, that could add the weight of its simulations and projections to the many other political forces in the larger arena of public debate.

To be sure, a state wherein more and better predictive models of the policy-to-structure-to-output variety were available would be welcome. This is almost inevitable due to the increasing complexity of social systems and increasing public awareness of the interrelatedness of the many factors in a decision. A first diagnosis of this paper is that we should be prepared to contribute to improved products of this type, but that we should do so in the awareness that what science can contribute is nothing more than illustrations; we must temper our enthusiasm for prediction with an assessment of the limitations of the methodology we utilize. In this regard, CANGO and Regional Futures offer two examples of models with explicit awareness of limitations. Their strength lies precisely in what they *do not attempt to do, and in the self-consciousness with which they do not do it.* Their utility in the policy environment is their flexibility to incorporate value judgments or best thinking other than those of the analysts involved in their construction.

A second possible evolutionary direction deals with the forgotten upper-left quadrant. As the repercussions of past and present policies become more evident and better understood by larger segments of the population, we should expect to face more complex feedback from individuals and organizations. It could be hypothesized that an increasing amount of interpretation of such feedback will become the responsibility of policy analysis. A second diagnosis, therefore, is that we need collectively to begin to compile methods and experiences in the most complex area of social science, namely, the social aggregation of individual preferences and its representation in terms of policy objectives.

In concrete terms this means to learn how to analyze contexts that give rise to changing values, the interrelations between such values and the societal implications of their configurations. The agenda is broad indeed.

Integration and Level of Regional Development

M. Penouil

Is it possible to have a universal and permanent approach to the problem of regional integration? First I propose to discuss the effects of international integration, e.g. the European Community (EC), on regional integration. Can growth in the size of communities influence the process of integrated regional development (IRD) and its structure? Then I want to talk about the influence of the level of development on regional integration. Are these determinants the same in developed and developing countries?

I have chosen to approach these problems in a concrete and descriptive manner, since before theorizing it is necessary to determine the boundaries of action. I shall speak about two examples. The first is a region in the south-west of France. The second is quite different: regional integration or disintegration in the Ivory Coast, Africa.

The first problem is complex: I choose two aspects.

Has the EC reinforced the integration of Aquitaine into the French economy? I think that in 1958, Aquitaine was an underdeveloped region of France: the income was lower, than in many other regions, and industry was less than 25 percent of the GNP. All other economic indicators showed the same thing. The irregularities in income are of less importance, but it matters that the economic structures are very weak. I have not time to analyze the situation in detail, but I think it is possible to present a hypothesis for a model. IRD is influenced by economic, social, and political systems.

At the economic level, the EC has a large influence, but the location of industries are influenced by ordinary factors--natural resources, manpower, infrastructure, cost of transportation, etc.--so it is easy to explain why the direct influence of European integration was low in Aquitaine.

But we also have the social aspect with its influence for a more equal income distribution. The influence of trade unions and of politicians balance incomes and particularly wages between regions. Wages first grow in developed regions and then in others, whereas income from the state is at the same relative level in all regions even if generally more important in underdeveloped parts. So we have national processes neutralizing the European processes and reinforcing integration.

In fact, regional policy is not the first preoccupation of government. In France the hierarchy of national policies is:

- To maintain and reinforce enterprises,
- To open the national economy to world competition,
- To assure social equilibrium,
- To realize economic equilibrium between inflation and recession, and
- To plan the national economy.

This fifth objective is dependent on the others and generally--except for social equilibrium--there is conflict between the interests of the national economy and of the less developed regions. So the development of these regions is often a source of economic difficulty especially since it means a growth of incomes.

There is a strong probability that Spain will join the EC. In this case, it will be very interesting to organize research to analyze its evolution now and after integration. Spain is characterized by a strong inequality between regions and the more important regions are near the north boundaries. Will the EC be a factor of disintegration for Spain? If Spain joins the EC, will Aquitaine be more integrated in the EC? If we analyze the present trade between Aquitaine and the north of Spain it is not clear-cut, but we do not have now, all the elements necessary for a good analysis. I think it is an important problem from the theoretical and political points of view.

The second part of my contribution is quite different. It is the problem of relations between the level of development and regional integration. I think that the problem is quite different in the underdeveloped countries. My example is the Ivory Coast, partly because I know it, but mainly because it is an interesting case. It is a little country in west Africa. It has now about 6 million inhabitants, but only 3.5 million in 1960--a most important rate of growth of population in Africa, since migrations to the Ivory Coast are very important. It has no mineral resources, and one of the most important rates of growth of national product--particularly of industrial production. It is a country in which regional problems are particularly important for its future growth.

The Ivory Coast is not now an integrated society. From a geographical point of view we can distinguish two parts: north and south; the wet and the dry; the rich and the poor. Integration is linked to equalization of growth rates between north and south and to an equalization of natural resources distribution. But the normal process is quite different. It is a process of disintegration, with the south growing fast and the north growing slowly. The south makes exportable products and can be integrated into the world economy. The north has domestic productions and it is difficult to influence its growth, because interregional and intersectoral exchange does not exist.

There is another aspect of the problem. The Ivory Coast can be seen as having a dual economy with a modern and a traditional sector. The first is characterized by market and capitalistic processes of production. The second is based on autoconsumption and production with labor only. This second aspect is linked to the first: the economic development of the north will be effective only if the market economy can progress or if industries or modern agricultural activities can be realized. But this traditional view is partly wrong. We have in fact a three sector economy: modern, traditional, and "transition" (sometimes called the informal sector).

What is a transition sector? It is a sector with very low monetary income, with noncapitalistic processes of production, and with a very low quality of product and services. But it is a sector in which modern needs exist and cannot be satisfied by the modern sector of production because prices in that sector are too high for the level of income. For example, when a car is 10 years old and when nobody in the modern sector can use it, it is bought by a man in the transition sector. It is possible to transport 10 people in it. It is never repaired but if possible it will transport people for another 10 years or more. It is dangerous but it is very cheap. We have in fact two markets with very little integration.

The transition sector is very important. In Abidjan the population was less than 100,000 in 1960 and is now nearly 1 million. Employment in the modern sector is now less than 50,000. Where are the working people? In the transition sector! The growth of the town population cannot be explained only by the appearance of modern activities. The same applies to the greater part of the rural areas, especially in the north.

The transition sector cannot be easily integrated into a systems analysis. There are no links between the modern and transition sectors, or, if there are, these links are without great influence. The society is not integrated not only from a regional point of view, but also from the sectoral point of view (no relations between the different productions) and the structural point of view (the problem of no market economy, modern market economy, and transition market economy). Hence, decisionmakers do not work efficiently. They are generally working in the modern sector which has less than 10 percent of the total population of the Ivory Coast. The growth of the transition sector is a natural phenomenon not caused by political decisions but by the evolution of the population's attitudes and needs. It is very difficult to integrate this sector in a national policy, for public money creates a few more modern works that in turn create new growth in the transition sector.

In conclusion, the two different approaches to our problem, concrete and descriptive, and methodological and abstract are good and necessary. The first can be used to limit the abilities and boundaries of theoretical hypotheses. The second is necessary if we hope to find a method suitable for many countries. My Institute will be working on the case of Spain and Aquitaine, but I think it will be good to study two or three other developing countries, similar to the Ivory Coast, but where the process of regional integration is probably rather different. Socio-economic indicators of regional development will be useful for comparing different situations. In Bordeaux, we can work with IIASA on the problems. As far as the methodological approach is concerned, I think it is possible to work first on input-output analysis. But this is certainly not sufficient, and a next step will be to integrate other factors.

FINAL DISCUSSION SESSION

Discussion Session

The following three questions were focused upon during the discussion session:

- The main direction of the IIASA Integrated Regional Development activities.
- The role that case studies will play in the Integrated Regional Development activities.
- The character of IIASA's relations with an international scientific community and the NMOs.

Opening the discussion, Professor Walter Isard underlined that the success of any research effort depends very highly on the personalities involved. Using this as a starting point he proposed concentrating the IRD activities on the study of industrial complexes and at the same time to investigate the efficiency-versus-equity problem. For the former problem, IIASA has experience and a network of connections with scholars and organizations already set up. For the latter, he pointed out that the world has so far failed to come to grips effectively with these equity problems.

Dr. Roger Levien's main point, at this stage, was that one could not propose this to Council as something IIASA should work on because there are a lot of proposals such as these. Regional development means so many different things and is such a broad subject that one should seek a focus of this broad theme.

As an example of this, he mentioned the IIASA Energy Program. This Program has a <u>theme</u> that allows, in principle, isolation of the topic that one might want to deal with and the level of detail at which to study them. The theme of the Energy Program is the transition during the period 15-50 years from now, from an energy economy based on oil and gas to one based on the relatively inexhaustible resources of nuclear energy, solar energy, and coal. The focus there is how one goes through this transition period; they are trying to understand what the nature of demand is going to be during this period and afterward, what the resources are, the options, and constraints, and the strategies. The structure of the Energy Program is clear to see: it is of a finite period, concerned with finite goals, practical problems, and so on. The same approach must be used for the regional development activities. One must look for something more specific.

The idea was discussed that the strategy for developing a new region undergoing, for example, a major exploitation of its resources, as the Lublin Coal Basin in Eastern Poland, or the regions of Siberia, or the Southwest Four Corner Region of the USA (Arizona, Colorado, New Mexico, and Utah), could serve as a focus, studying how one exploits a region when it had the no-growth of underdevelopment, and then suddenly there is a major resource to be exploited. Dr. Levien put the question then, as to whether this was a theme, and would it be enough of a focal point. He went on to mention that maybe another approach, which is based on previous experience of the participants of the IIASA staff, deserved to be realized. In this case the problems of the methodology of constructing industrial complexes in new regions, not only in countries with planned economies, but also in those with market economies, should be analyzed.

Dr. Ross Millar proposed that IIASA should be looking toward the synthesis of what we know about the structure relationships, i.e. the universality in some sense of what we are seeking, and then to construct essentially transparent models that allow these universal themes to be seen. That is what allows the work to be truly applied, because if it is not transparent, it cannot be applied. It is in this area where IIASA, because of its ability to cross international boundaries, its ability to cross analytic disciplines, gets its comparative advantage, i.e. the slightly theoretical or academic scenario approach. The IRD activity could be done on a more modest scale than one that attempts to attack and develop new approaches to a variety of regional science problems.

Dr. Laszló Láckó proposed that IIASA make an evaluation--a kind of summary of regional planning and regional research, academic at least--of the achievements of different NMO and other countries. It should, in his view, include a section dealing with the place of regional planning in national economic planning in different countries, because the meaning of regional planning and regional planning growth is different in different countries. These distinctions could help make IRD activities clearer and promote them. The methods should not be limited to modeling.

Professor Ryszard Domanski underlined that IIASA should decide, not problems, but types of problem areas, of problem regions: for instance, developing or developed regions that are being reconstructed, rural regions in modern and developed economies, regions in post-industrial societies, and so on. We should start with a statement of the types of problem areas or regions that we consider to be worth investigating.

The necessity of conducting a system-analytic approach to IRD problems was stressed by Professor Wrobel. The systematic methodology might enable us to take into account all of these models, links between regions, and so on, which have already been missing in the elaboration of many regional development plans so far.

With regard to the role of case studies undertaken within the IRD activity, Professor Andrei Rogers emphasized that although to scholars it is terribly important that knowledge is accumulated, to the NMO it is more the dissemination of knowledge that is important. This creates the case study problem. The demonstration of existing state-of-the-art knowledge and dissemination among the NMOs, and the conflict between the two, arises in all definitions of research tasks at IIASA. Not surprisingly, it is a problem in IRD research also.

Dr. Levien then stressed that it is exceedingly important for IIASA to be engaged in case studies; not only for knowledge disseminated, but knowledge applied. Being in touch with real problems is useful; but it is also useful to stimulate good research. This should not be 100 percent of IIASA work; some portion should be on case studies, and some portion on generalizing. The principle is, that we should not be driven by the cases, but rather the cases we choose to work on, should be related to our common theme.

The third question--the character of IIASA external relations--was discussed from the viewpoint of increasing the Institute's abaility to use international experience and to influence on-going works.

Professor Isard said that the linkages with the existing network of scholars in institutions and associations are also a matter of importance. Although the linkage to NMOs is good, to do really successful research, informal linkages are needed with scholars with common interests, at international organizations such as the economics and international economics organizations, the International Geographers Union, the Regional Science Association, the organizations concerned with operations research, and branches of applied mathematics and statistics, and the World University. There are many existing world-wide conferences on regional problems and IIASA ought to be more closely involved with them. It would mean that less IIASA resources would be used.

Dr. Levien welcomed the idea and proposed IIASA should be a co-sponsor of international meetings as it is already with IFORS, IFAC, etc.

Professor Domanski suggested that IIASA should co-sponsor the Regional Science Association World Conference next year or sometime in the future.

Dr. Levien also proposed choosing five world-ranking scholars to visit, work with, and advise the Integrated Regional Development activity at IIASA. This system should also include scientific liaison officers to have contacts in the communities in each country in order to benefit from the work going on there, and to contribute in some way to that community.

SUMMARY STATEMENT

Summary Statement

The Task Force Meeting on Integrated Regional Development (IRD) was held on 19-21 April 1977. There was an intensive exchange of viewpoints on the fruitful directions for IIASA's future IRD research activities in the Discussion Session (some of which is printed in this volume) and there was a great deal of sharing of past research experiences. Many of the IRD problems faced by individual National Member Organization (NMO) countries were discussed; participants from 13 NMO countries were present. Among the important topics ventilated at the meetings were:

- The feasibility of a universal approach towards IRD problems in all the NMO countries.
- The main principles for classifying and delineating IRD problems--and problem regions.
- The issues of coordinating national and regional objectives.
- An evaluation of the IRD experience in the NMO countries from the viewpoint of its applicability within IIASA.

The participants represented not only many different countries, but also different research backgrounds, different disciplines. Nevertheless, there was a broad concensus about a number of items:

- More emphasis should be placed on cooperative efforts, not only within IIASA, but also with interested groups in the NMO countries and with the whole scholarly community. It was recommended that IIASA cosponsor meetings on IRD related topics with scientific and professional associations, such as the Regional Science Association.
- The thrust of IIASA's IRD work should be not only on the accumulation of new knowledge, but on the dissemination of knowledge, and on the application of the knowledge gained to the NMO countries. From this viewpoint it was stressed that the IRD work within IIASA should build upon the IRD work already done within the NMO countries; use approaches that would be acceptable by the NMO countries concerned; develop theoretical analyses in parallel with the practical work; design mathematical models for which data would be available, and generally seek to maximize the likelihood of achieving practically useful results.

- It was recommended that liaison researchers in the NMO countries be nominated and that their task would be to elaborate plans or programs for the support of the IRD activities in individual NMO countries.

- Finally, it was recommended that a conference on IRD problems with worldwide participation be organized in 1978 or 1979.

APPENDIXES

Appendix 1

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Appendix 2

Draft Proposal

The participants of the IRD Task Force Meeting of 19-21 April 1977, represented the following countries: Austria, Canada, the FRG, France, Hungary, Italy, Japan, The Netherlands, Poland, Sweden, the UK, the US, and the USSR. Many different problems and issues were presented and discussed. Among the most important were the following:

- Feasibility of a universal approach toward IRD problems in all NMO countries.
- Main principles of classifying and delineating IRD problems.
- Problems of coordination of national and regional objectives.
- Evaluation of the IRD experience in the NMO countries with reference to its applicability within IIASA.
- Possible organization of cooperative efforts in IRD explorations (cooperation within IIASA, cooperation between members of the IRD group and experts in other research Areas, and cooperation with experts on IRD problems in the NMO countries).
- There was general agreement among the participants that the following requirements for any IIASA IRD work must be met:

  (a) The general idea of IIASA's IRD activities is not only to elaborate its own approach, models, and so on, but firstly to build upon the results already achieved in the Institutes of NMO countries.

  (b) The necessity of elaborating a system of models in such a way that the likelihood of achieving practically fruitful results is maximized.

  (c) Development of the theoretical analyses must be done in parallel with the practical work.

  (d) IIASA's IRD models must be designed specifically from the required information.

(e) Every part of the models elaborated in IIASA activities must be approved in one or more NMO countries.

- All the participants agreed that IIASA IRD work must include the following:

  A general concept of IRD,

  A methodology,

  A system of models, and

  Case studies.

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