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Demometrics for Regional Development

J. Ledent*

Population growth is not only the consequence of economic growth, but also a cause for it, especially at the regional level. Thus, to be helpful to decision makers, regional development analyses should not only stress—as they often do—the impact of economic growth on population growth (i.e., migration), but should provide a full picture of the interaction of population and economic growth. One activity of IIASA's Human Settlements and Services Area is currently devoted to developing an adequate framework for conducting such analyses. It puts forward the demometric approach, one that applies econometric methods to the combined analysis of population and economic ("demoeconomic") growth.

Demometrics in a Regional Setting

In a broad sense, the demometric approach calls for the application of mathematical and statistical methods to the study of demographic phenomena. Its practical aim is to establish empirically quantifiable relationships between demographic and economic variables. These relationships make it possible to infer an *explanation* of such demographic phenomena; they permit a *forecast* of their future evolution; and they constitute a basis to determine the implications of *planning* policies concerning those phenomena.

The application of the demometric approach to regional development calls for the construction of models describing relationships amongst major components of regional demoeconomic growth (output, employment, population, birth rates, migration rates, etc.). However, the development of such models is hampered by several limitations, which relate to

- the unavailability of a meaningful theory of regional development;
- the inability of modelers to design constructs dealing with population and employment in a consistent way; and
- the lack of an adequate data base.

The first two problems are examined in detail later on. As for the last one, there is a chronic lack of data over a long period of time relating to socioeconomic variables for local areas. It is especially acute for demographic variables, which in turn leads to a reduction in scope of many regional development analyses.

Theoretical Considerations

Since no model can be built without some guidelines provided by theoretical considerations, the availability of a theory of regional demoeconomic growth is a prerequisite to the construction of regional growth models.

Unfortunately, no adequate theory has yet been developed. The traditional explanation of regional development coming from Keynesian economics, (export base theory) is that an area's

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growth is determined by the factor "demand" only. There exists no constraint from labor inputs: workers attracted from other regions by the jobs created are always forthcoming in sufficient quantity to satisfy demand. In other words, according to this explanation, which views population growth (in this case migration) only as a consequence of economic growth, people chase jobs.

By contrast, the recent literature, influenced by neoclassical economies, argues that an area's growth only arises from the growth of its labor inputs.* The number of workers available in a region determines the level of production which is not affected by "demand". In this case, population growth is seen as the cause of economic growth since enterprises follow workers.

In reality, these two polar explanations of regional development are not mutually exclusive. This has been shown by several recent empirical studies** based on simultaneous equation models: their results indicate that both enterprises and people actively participate in the process of spatial demoeconomic growth. Nevertheless, such models have not permitted solving the major problem: the identification of the sources of regional demoeconomic growth.

Thus, in the absence of a fully meaningful explanation of regional development, the establishment of a theoretical framework is of paramount importance in applying the demometric approach. A minimal framework capable of underlying a regional demometric model has now been developed at IIASA.

It relies on the separation of the forces creating the conditions of growth (driving forces) from those speeding up (or slowing down) the ensuing growth process (facilitating forces).

The first type of force relates to enterprises to the extent that their location depends on nondemographic factors (i.e., factors unrelated to labor inputs), such as the availability of cheaper raw materials in a particular place, or the existence of a good transportation network. It also concerns those people moving for primarily noneconomic reasons who can have an impact on the development of both their origin and destination through:

- their consumption of local products (this is the case of students, military personnel and retirees), or
- their participation in the labor force (this is the case of workers attracted by amenities such as climate, etc.).

The second type of force relates to the short term dynamics of the local labor market, that is how entrepreneurs anticipate changes in labor supply and how migrants anticipate the number of forthcoming jobs.

The essential role of demometrics in a regional setting then is the specification, estimation and testing of the significant (driving and facilitating) forces determining the growth process, and the examination of their relative importance in a quantitative manner.

Consistent Demoeconomic Modeling

From these theoretical considerations emerges the conclusion that the key issue of regional development evolves around the confrontation of labor supply and demand in a multi-market system, which results in simultaneous population and employment growth (or decline) in all local labor markets. Thus, a regional labor market cannot be considered in isolation.

It follows that a regional demometric model must:

- describe the actions of enterprises and households, local as well as external, which affect the functioning of the regional labor market (i.e., the driving forces), and
- examine the meeting of their respective expectations (i.e., facilitating forces) which allows the connection between labor dynamics and migration to be made.

As in most cases when supply and demand are confronted, the modeling of mechanisms of the labor market raises some technical problems, especially complicated by the fact that supply commonly remains higher than demand. In brief, the characterization of the interaction of population and employment growth, mainly through the impact of the labor market surplus (unemployment), raises a consistency problem which is due to the nature of labor force participation and unemployment rates. A careless modeling of a regional labor market, as illustrated by past models, is likely to yield nonplausible values for the labor force participation and unemployment rates, which lead to inconsistent values for the three main labor market variables.

A Case Study. A Multiplier Analysis for Tucson, Arizona

The full application of the demometric philosophy to a comprehensive analysis of shifts in employment and population within a country is hardly possible today because of the limitations just discussed. The research undertaken at IIASA has so far succeeded in partially overcoming some of these limitations in that a minimal theoretical framework, has been defined, and a consistent population-employment modeling has been developed. This progress has been sufficient to permit the analysis of small policy programs relating to regional development. One of the problems that has been treated concerned the impact of job creation in a regional economy exhibiting a particularly rapid population growth.

As a substitute for the traditional equilibrium model based on the export-base theory, a disequilibrium model was built and fitted to data for the rapidly growing metropolitan area of Tucson, Arizona. It allowed the derivation of meaningful multipliers bearing a time dimension, i.e., expressing the evolution over time of the impact of job creation on the local economy, which results mainly from the dynamic character of population growth. For example, it was calculated that an increase of 1000 jobs in 1976 in the mining sector (copper extraction being a leading activity), would have led to the creation of 4140 additional jobs within three years, of which 3370 would have taken place immediately. The corresponding effect on population would have been the inmigration of 6910 people within three years (2760 in the first year). Also very interesting was the additional result of a sharp increase in labor force participation and a drop in the unemployment rate, suggesting that the jobs created would not be totally taken by inmigrants, but would also be beneficial to resident workers, either unemployed or outside the labor force.

Conclusion

A simple demometric model, proposing reasonable solutions to the theoretical and modeling limitations generally encountered in regional development analyses, has improved the quality and accuracy of analyses of rapid population growth.

The results obtained are encouraging enough to suggest the value of further development of the demometric philosophy to examine the implications of more sophisticated policies concerning regional demoeconomic growth.

*This theory was first suggested by G.H. Borts and J. Stein in Economic Growth in a Free Market, Columbia University, N.Y., 1964.

**For example, those of R.F. Muth ("Migration: Chicken or Egg?" Southern Economic Journal, vol. 37, 1971, pp. 295-305) and M.J. Greenwood ("Urban Economic Growth and Migration: Their Interaction" Environment and Planning, vol. 5, 1973, pp. 91-112).

Obergurgl, Revisited

Four years ago, IIASA was asked to assist scientists of the University of Innsbruck in taking a systems view of the environmental impacts of tourism in one of Austria's Alpine regions. A model was developed that enabled local decision makers to see—amongst other things—some of the results of a rapid growth of tourism. Since then, work went on without active participation by IIASA. A seminar organized by the Bavarian Academy of Nature Conservation and Landscape Management (FRG) provided an opportunity to find out what happened since.

People living in the Alpine regions of Europe are getting more and more concerned about their environment. They become aware that tourism does not only mean potential wealth for formerly poor mountain communities—they begin to realize that it also means unexpected side-effects, often harming the environment. Obergurgl, a small village in the Tyrolean mountains, almost 2000 meters high, has experienced both the good and the bad sides of this development. With a resident population of only 200, it hosts some 40,000 tourists every year—skiers in winter, alpine climbers in summer. It has invested much in the facilities tourists nowadays expect in a modern holiday center: chair and T-bar lifts, hotels, pensions, discotheques and restaurants, swimming pools and saunas.

Photo: OFW

Before the growth of tourism, this agricultural village was one of the poorest in the whole region, cut off from the rest of the world during the long winters. There was barely enough food for all; population growth had to be restricted: during the last century for some 20 years, marriages were forbidden in Obergurgl in order to prevent the birth of children, and many people were forced to leave the village to search for employment.

But then came the age of tourism, and things rapidly changed. Money started flowing into the village, hotels were constructed, the population increased. People moved out of agriculture and into the new industry. Many farms were in danger of being abandoned, although it had been agriculture which had shaped the typical Alpine environment for which the tourists came.

A Systems Approach

It was against this background that the Alpine Research Institute in Obergurgl, a branch of Innsbruck University founded in 1951, decided to undertake a systems approach to the problem. Being involved in UNESCO's Research Program "Man and the Biosphere 6" on Alpine Regions since 1972, Dr. Walter Moser, head of the Institute, approached IIASA in 1974 for assistance in building a simulation model of the village. In two workshops at Laxenburg and Obergurgl members of IIASA's Ecology Project (since incorporated in the Institute's "Resources and Environment" Area), together with scientists working at Obergurgl and inhabitants of the village, created a first version of the "Obergurgl Model".

This early version of the model was not sophisticated, running on a very small computer with limited capacity. It nevertheless provided new insights into the impact of development on the fragile Alpine environment and for the first time gave local decision makers an idea what the continuing human activities could mean for their small community: disturbance of an extremely sensitive environment, "overpopulations" of tourists, leading to decreasing numbers of tourists in later years; and finally lack of jobs, again causing a wave of outmigration.

The model at that time was mainly designed to deal with four major areas:

- recreational demand,
- population and economic development,
- farming and ecological change, and
- land use and development control.

In 1975 this model was transferred to the scientists of Innsbruck University and the IIASA involvement in the Obergurgl studies came to an end.

As research goes on...

But the initial work was found to be of sufficient value for the Obergurgl Institute to continue the research. Primarily Austrian scientists from many disciplines in a truly interdisciplinary effort refined and modified the original approach. Biologists, geologists, demographers and ethnologists together with many others, collected further data to be incorporated in a new computer-based model, which also makes use of know-how from economics, regional planning and technology.

The present approach has focused on two major aspects of the problem: land types available and the way they are used, each shown in a large number of sub-components. The data obtained by field research are matched to these components wherever possible. As usual, much of the data need reinterpretation, which means tedious searches for new methods to utilize them in a meaningful way.

Work at Obergurgl is not finished and will go on for a number of years, as much remains to be done. But the important objective of providing decision makers with analytical tools has been reached already.

...the people decide

While during the early years of the project the "Obergurglers" were rather skeptical about the activities of the scientists asking unusual and unfamiliar questions and trampling through their meadows, they are now actively cooperating with the researchers. Some of them have become interested in scientific explorations and started studying the local fauna and flora. Ground erosion through touristic activities is now being carefully watched and restricted to a minimum. Moreover, the villagers now are aware that their decisions about economic growth can be based on facts and need not rely on intuition alone.

And finally, and possibly most important of all, the "Obergurglers" have realized the overrriding importance of agriculture for their valley. They have therefore decided to start on a program of subsidization of those members of their community who are still engaged in agriculture. It is hoped that this will provide them an incentive to stick to their hard and tiring jobs instead of leaving agriculture altogether and thus preserve this form of acitvity so vital to the future of Obergurgl.

Gaming in Systems Analysis

O. Helmer*

The main purpose of systems analysis is to provide an integrated approach to the study and management of complex systems.

Such systems invariably are characterized by social, technical, legal and environmental features, as is the case, for instance, for a firm, a city, a transportation system, a nation. Moreover, these features of whatever system is being considered and the aspirations and values of the managers of the system are generally so intricately interwoven that the systems analyst needs to include the managers as part of the overall system he is investigating. As a consequence, systems analysis inevitably involves interdisciplinary considerations. And often, numerous disciplines come into play, such as physics, chemistry, engineering, economics, sociology, political science, ethics, ecology. In particular, it should be noted, the relevant disciplines always include some which belong in the realm of the social sciences.

An activity involving a planning effort is, by definition, future directed. This clearly applies to systems analysis.

...and intuitive methods

It is therefore rather futile to try to proceed in a complex planning context by formal theoretical means. In order nevertheless to employ an orderly planning procedure, it becomes necessary to search for informal, intuitive methods of gaining the insights required to make forecasts of future operating conditions and of the consequences of contemplated actions.

Obviously the quality of decisions based on intuitive forecasts depends on the reliability of such forecasts; this reliability, in turn, depends greatly on the level of expertise of the forecasters. Therefore the need for care in selecting experts as forecasters and in eliciting and utilizing their forecasts cannot be overemphasized.

Once it has been accepted that the use of intuitive judgement in systems is not a temporary expedient but a permanent and integral part of its normal procedures, it becomes imperative that orderly methods be employed by which judgemental contributions are utilized as effectively as possible.

A singularly productive method to this end, applicable to groups of experts, is that of operational gaming (also known as interactive simulation), which involves using a particular kind of simulation model that includes role-playing.

Past experience with simulation models, especially when they are multidisciplinary, suggests that they can be instrumental in motivating the participating researchers to communicate effectively with one another; to learn more about the subject matter by viewing it through the eyes of persons with backgrounds and skills different from their own; and thereby, above all, to acquire an integrated overview of the problem area. Especially important to note is that this catalytic effect of a simulation model is produced, not only by the employment of the completed model, but equally by the process of constructing it.

Precondition: Reliance...

The multidisciplinary and future-directed character of systems analysis makes some reliance on judgemental inputs indispensable. To see that this is so, it is only necessary to reflect on the conditions under which judgement-free conclusions, applicable to real-world planning, are drawn. Such conditions include the presence of data derived from observations, the existence of a coherent, well-confirmed, and objectively testable theory establishing correlational and, if possible, causal connections among the observed phenomena, and the application, through extrapolation, of such a theory to the future consequences of contemplated actions. This is the pattern followed, by and large, in the case of straightforward engineering applications of the laws of physics.

These conditions are not satisfiable in the context of a typical systems analysis. First of all, well-confirmed theories are rarely available in any of the social sciences, and all we have are, at best, mildly confirmed "ceteris paribus" (without changing other factors) regularities. Secondly, even if such well-confirmed interdisciplinary theories were available, their applicability to determining the future consequences of planned actions would be questionable, because the ceteris paribus condition (the invariance of the operating environment) would generally be violated. were available, their applicability to determining the future consequences of planned actions would be questionable, because the ceteris paribus condition (the invariance of the operating environment) would generally be violated.

Players as Decision Makers

The effect of collaborating on the construction and use of a simulation model is particularly powerful when the simulation takes the form of an operational game, where the participants act out the roles of decision makers. By being exposed within a simulated environment to a conflict-of-interest situation involving an intelligent opposition, the "player" is compelled, no matter how narrow his specialty, to consider seriously many aspects of the scene that might not normally even occur to him when he works in isolation. Thus, the game laboratory induces an integrating effect amounting to a systems approach to the subject matter.

While operational gaming has been employed for many diverse purposes, such as teaching, training, experimentation, and planning, its use to the systems analyst as a technique that aids the intuition and stimulates the inventive imagination is perhaps the most important mode of application. Indeed, when used in this heuristic fashion, the gaming activity—both the playing of a game and, even more important, the designing of the game in the first place—serves as a self-educational device for the planner or the analyst acting as a planning advisor. Such heuristic gaming represents a trial-by-error process that involves a complex feedback relationship between inventing and testing. The inventive portion of the effort consists in the selection of appropriate elements to be included in the game model and of promising strategies to be tested as to their being adequately close to an optimal solution. Testing through actual gaming, on the other hand, may yield information on relative sensitivities, thus suggesting the elimination, or addition, of conceptual elements from, or to, the model, as well as the formulation of other strategies to be subjected to examination.

The role of gaming as a medium through which to elicit the ideas and opinions of experts is evident from the foregoing discussion. The process of interactive simulation, in fact, constitutes an

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ordered structure that encourages cross-disciplinary communication, stimulates both the production of ideas and their critical review, furthers a clearer intuitive understanding of the subject matter, and thereby provides the basis for at least tentative theory formation in areas where no established theory preexists.

For reemphasis it should be stated once more that there is no guarantee that expert opinions will in every instance, or even most of the time, be correct. Thus the results of gaming, which relies heavily on judgemental inputs, must always be taken with a grain of salt, and it can only be hoped that the lessons learned from gaming activities are, by and large, conducive to more effective planning. Fortunately, experience seems to confirm this, and it is fair to say that, as a heuristic aid to intuition and a tool for interdisciplinary cooperation, operational gaming appears to have no equal at this time.

Gaming at IIASA

The utility of gaming as an aid to systems analysts is currently under close examination at IIASA. A complex six-player demonstration game, GEM (for "global economic model") which was developed last year, has since been somewhat refined, and is currently being tried out in a workshop involving the 1978 summer graduate students. Each of the players in this game is responsible for running the economy of one of six world regions and for making trade arrangements with the other five players. Another game, designed and run jointly by the Food and Agriculture Program and the Management and Technology Area, simulates development problems of the Brazilian agricultural economy; its purpose is to gain insight into the interrelations between economic and sociopolitical policies in a developing country and thus to identify promising development strategies. Late in August of this year, the Management and Technology and the Systems Decisions Sciences Areas held a workshop intended to investigate the utility of gaming as an aid in policy formulation and implementation. Representatives of IIASA's National Member Organizations and a group of experts in simulation gaming participated in this workshop; its outcome will have influence on the extent to which gaming will be more actively pursued at IIASA in the future.

The Economics of Today's Population Trends

W.B. Arthur*

New analytical methods are bringing fresh insight into an important problem: how will current population trends affect our lives in the years to come?

In the last few years in the Federal Republic of Germany, married women have been giving birth to fewer children than ever in the nation's history. In the last few years in the United States, unprecedented numbers of young people have arrived at working ages, jostling each other for places in factories and in the professions. And in the last few years in the Soviet Union, more elderly people are alive, and are living to riper ages than ever before.

What are the long-term consequences of today's population trends? How will present changes in population structure affect us and our children over our lives and careers?

To explore these questions, we require new methods. We need a skillful blend of economic theory, demographic analysis, and modern mathematics. Within System and Decision Science's Economic Planning Task, we have been developing new techniques that

- Widen neoclassical economic models to take full account of population age structure and of age-related variables such as mortality, fertility, and labor participation.
- Measure economic consequences on a life-cycle basis. (Standard economic indices such as per capita consumption are largely blind to age structure changes.)
- Use mathematical tools such as variational calculus and Frechet theory to derive effects of changes in the shape of demographic age patterns.

What insights do these new methods bring us? What new problems can we tackle? Let us look at 3 specific examples: the economic consequences of today's low birth rates; new problems in the economics of the job market; and the pros and cons of people living longer.

*Dr. Brian Arthur joined IIASA's System and Decision Sciences Area in March 1977. He was previously associated with the Population Council, New York, and the Department of Economics, University of California, Berkeley and has written and consulted extensively on economic planning and on population.

Today's Low Birth Rates: Too Low?

Birth rates are at their lowest ever in many countries both East and West. Most economists would argue that this allows a better balance between productive resources and number of people. Recently, however, Nobel Laureate Paul Samuelson, writing in the "International Economic Review", shows that low birth rates may be a major cause for concern. Samuelson argues, in essence, that with fewer, young productive people coming behind us to finance our support later in life, either we will be more poorly supported or they will be unduly burdened. People will lose.

But are Samuelson's worries justified? To answer this, we must go back to questions of methodology. Samuelson's analysis is an elegant piece of economic theorizing, but the population side of his model is scant. It allows only 2 age-groups, young and old, so that if there are fewer younger, productive people the old and dependent naturally will have thinner support. But looking at the question again, and widening the model to include all age-groups, we see that Samuelson's argument could work the opposite way. Full age-group accounting allows support to flow not just from the young to the old, but from the young to the still younger—their children. Fewer children following us could be better supported. Thus what we lose as old people we may make up earlier as children, perhaps more than make up if flows of support toward children outweigh flows toward the elderly. Further analysis, by Geoffrey McNicoll and the author in the "International Economic Review", shows that whether this generational support effect works for or against low birth rates hinges precisely on whether the economy's producers are on average older than the economy's consumers. The figures show that in fact they are older. In both developed and less developed countries children cost more than older people to support —net support flows toward the young.

Therefore, even though today's low birth rates threaten to make old-age support harder to finance, they will more than compensate by easing the burden of child-support.

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Today's Population Trends

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Labor Bulges and Job Crunches

In many countries lately, growing numbers of young people—the 1950s Baby Boom came of age—have been crowding into labor markets, trying to find factory jobs or places in the professions. Although by now many have secured positions, their problems may not be over. All through their careers people in this baby-boom age-group will have to compete with larger numbers. For them, attainment of senior positions will be slow.

How do the ups and downs of birth rates affect career advancement? In a somewhat simplified way, we can think of the job profile of any profession as roughly pyramid shaped—few generals, many lieutenants—and the age groups that fill them, by and large, having older people at the top, the next oldest lower down, and so on. If a particular age group is large, as with today's 20-30 year olds, those behind them in seniority are pushed downward. If an age group is small, as with the 50-60 year olds in Germany who survived the war, those behind them rise to fill the vacancies and are more senior than otherwise. Together the profile or positions and the age pattern of members of the profession determine speed of advancement.

At IIASA we have been developing theoretical models built on these simple ideas to tell us precisely how much careers are accelerated or delayed by changes in age structure or in the job seniority profile. A case study that Anthony Cornford and the author are working on looks at the American university teaching profession. In the 1960s, US universities expanded their positions rapidly and many young academics reached full professorships quite quickly. Today conditions are tougher. Although the age-distribution within the profession has not changed greatly, jobs at all levels have become tighter, and a new law allowing 65 year-olds to retain their jobs to age 70 will take effect in 1982. Our preliminary results show that today's young academic will take on average 5 years longer to reach full professorship than his counterpart of a decade ago. The new retirement law will hold him up less than a year; most of the five-year delay is due to slower job expansion expected in the years ahead.

Life and Death

People are living longer in all countries. While each of us believes this to be a blessing, we would be hard put to say exactly why, in economic terms.

Take, for example, an imagined cure to cardiovascular diseases. In Europe, East and West, such a breakthrough would lengthen lives by an average of 12-14 years, most of the lengthening being where the risks are concentrated—late in life. It would be a major advance. Yet, the economist's usual measure of welfare, the index of consumption per head, would certainly not favor a cardiovascular cure. With a higher proportion of older, retired people, most of them consuming and not producing, the consumption per head index would be lower than otherwise. Nor would the breakthrough look especially worthwhile if one measures its success in raising net social product. The extra years of life occur when many people have retired from their jobs and are no longer productive.

How would our new methods tackle this problem? First we would widen our measure of economic "goods" and "bads" and ask what would be the net change in each person's well-being over his entire lifetime. Second, we would view a cardiovascular cure as a change in the intensity and shape of the mortality profile: the mortality pattern would fall at ages 55 and above. Finally we could put the two together, and ask what difference the new mortality pattern would make to the average person's economic life.

Carrying out this type of formal economic analysis, we find that if cardiovascular diseases were wiped out overnight, the representative man would feel four main effects. He would live on average 12 years or so longer and presumably he would value this, maybe quite highly. Chances are, he would be retired in these years; but on average he would produce extra economic output, about 1.5 year's worth in the United States of America. He would father more children, though this factor is negligible in the case of cardiovascular extension to life. Finally though, these important benefits carry an economic cost: the extra 12 years must somehow be financed, a by-no-means-negligible cost of between $50,000 and $75,000 per person in the case of Sweden. How? Possibly by private saving earlier in life, possibly by upkeep from one's children, but more likely these days by a pension system that everyone pays into in their younger years. Thus we see the main value of medical projects that promise to lengthen our lives—the pure enjoyment of added years of life, less of course the social-support cost of financing them.

This point of view, developed by the author, results in potential spin-offs to two other IIASA tasks. Research teams within the Energy Program and Management and Technology are interested in the economics of risks to life resulting from new technologies or industrial pollution. The described approach, which started from an abstract question of theoretical population economics, winds up with illuminating in a new and important way practical problems in engineering design or safety regulation.

Three new council members were welcomed by Professor Jermen Gvishiani, Chairman of the IIASA Council, at the last meeting of the Council beginning of June. Dr. Bruce Hannay of the US National Science Foundation replaced Professor G. Hammond from the US National Academy of Sciences, who also was Chairman of the Council's Finance Committee. The new representative for the Royal Society of London is Dr. B. John Mason, who took over from Sir Kingsley Dunham. And finally, Professor Alessandro Faedo's Council seat for the National Research Council, Italy, was taken over by Professor Guido Torrigiani.

Dr. Cesare Marchetti, member of IIASA's Energy Systems Program, has recently been elected an honorary member of the Engineering Society of the Toscana, Italy. Dr. Marchetti, who formerly was the head of the Materials Division at

Ispra, EURATOM's famous research center in Northern Italy, joined the Institute in January 1974 and is currently working on large-scale energy systems and questions of "geoengineering". Dr. Marchetti is also world renowned for his research efforts in the field of hydrogen energy.

News from IIASA

The IIASA Pest Management Network, initiated at a Conference at Laxenburg that brought together teams working on systems approaches to pest management in November 1976, after more than a year of preparatory work started operating this year by sending out papers to members of this network. The teams participating in the November '76 conference, which came from the USA, the USSR, Canada, the UK, and Japan, felt that, following their meeting, they should try to create a more permanent network of linkages and extend this to other scientists throughout the world who are interested in these approaches. IIASA agreed to sponsor and host this network as part of the program of its Resources and Environment Area. The network is intended to produce more than a simple exchange of information; specifically it is

- to identify critical problems of method and implementation and stimulate appropriate research, and
- to create a peer group, which can provide mutual criticism and encouragement for those engaged in developing systems approaches to pest management.

The network, which already has 140 members in 20 countries, is administered by an editorial and conference group consisting of G.R. Conway and G.A. Norton from the UK, who act as executive editors together with A.P. Gutierrez (USA), C.S. Holling (Canada), and A.S. Isaev (USSR). Members of the network are invited to submit working papers for circulation that are reviewed and edited by the executive editors and then distributed from IIASA. Enquiries about the network should be addressed to the Pest Management Network, Resources and Environment Area at IIASA.

1977 IIASA Statistics

Some 150 scientific institutions all over the world have actively collaborated in IIASA research during the year 1977. This means that the "core" of scientists working at the Institute is strengthened by scholars from 150 universities, research laboratories, and other scientific institutions. Also during 1977, IIASA expanded its joint work with and for international organizations and funding agencies. Cooperation with the International Atomic Energy Agency (IAEA) continued, and a formal agreement was made with the World Meteorological Organization (WMO). Bilateral collaboration was extended on an informal basis in fields of mutual interest with United Nations organizations, in particular with the United Nations Environmental Programme (UNEP), the United Nations Education, Scientific and Cultural Organization (UNESCO), the United Nations Industrial Development Organization (UNIDO), the Regional Economic Commission for Europe (ECE), the Food and Agriculture Organization (FAO), and the World Health Organization (WHO).

	YEAR				
	1973	1974	1975	1976	1977
• Scientist years					
– Supported by NMO contributions	8.6	48.3	66.5	63.8	63.9
– Supported by external funds	–	1.8	3.6	18.6	27.1
– Total	8.6	50.1	70.1	82.4	91.0
• Scientists (participating in in-house research for more than one month)	28	114	132	141	147

Table 1. Growth of scientific staff.

	YEAR				
	1973	1974	1975	1976	1977
Systems analysts	2	8	9	11	13
Engineers	4	16	17	21	15
Physical scientists	5	15	17	14	14
Mathematicians	4	12	13	15	16
Computer scientists	–	9	10	12	15
Operations researchers	3	14	20	9	11
Economists	2	10	12	25	31
Social scientists	2	10	14	13	12
Ecologists/Environmentalists	5	17	14	12	14
Biomedical scientists	1	3	6	9	5
Total	28	114	132	141	147

Table 2. Disciplinary composition of the Institute.

The 31 conferences, workshops, and task force meetings organized by the Institute were attended by well over 700 participants from National Member Organization (NMO) countries, plus many participants from non-NMO countries. And whilst IIASA registered 282 visitors from NMO countries (plus countless unregistered visitors), IIASA staff members paid 462 visits to countries represented at IIASA.

1977 publications included 3 commercial books, 24 research reports, 10 collaborative publications, and 60 research memoranda. The IIASA library's book stock has increased from 5400 in 1976 to 7000 in 1977; catalogue entries increased from 11,500 to 16,000.

And last but not least, the statistics indicate a further stabilization in the Institute's scientific staff: although the number of scientists working at IIASA still increased the average stay at the Institute also went up, as can be seen in Table 1. Table 2 shows the disciplinary composition of the Institute.

Recently Published

Collaborative Publications

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