International Institute for Applied Systems Analysis

OPTIONS

CONTENTS 1983/1

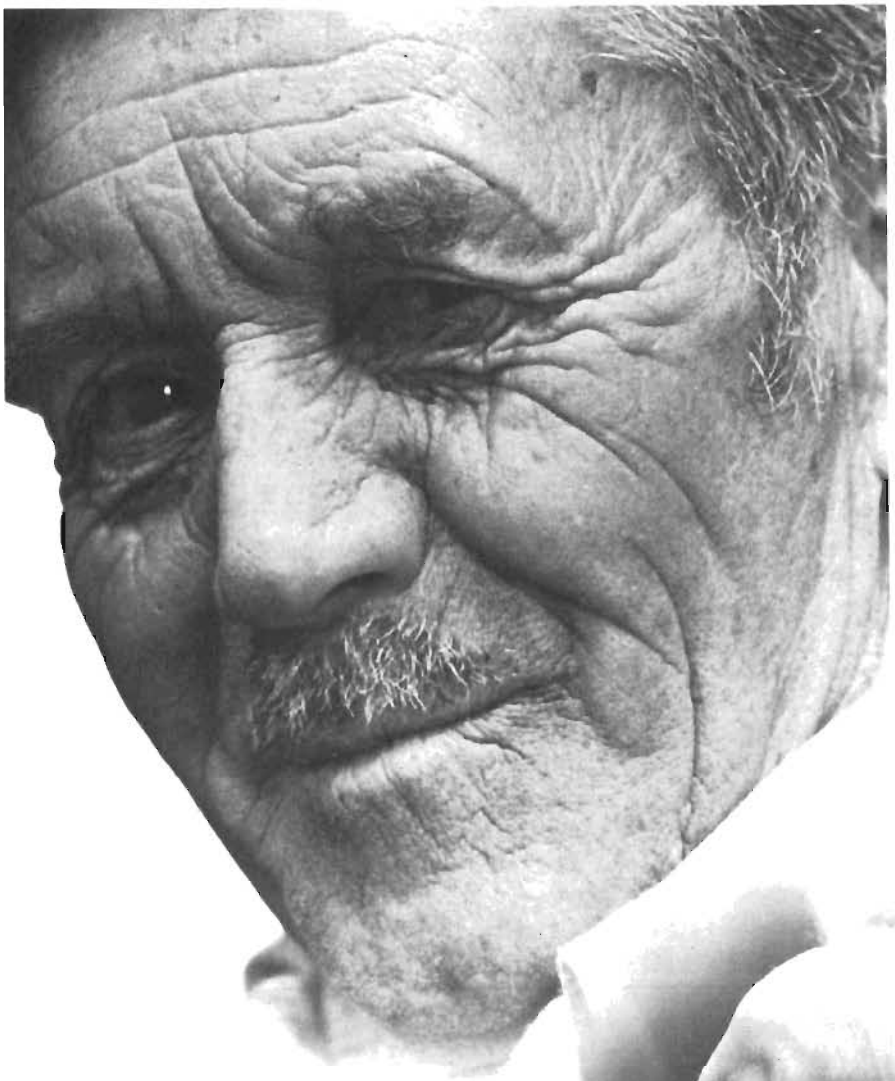
1 **Migration and Settlement**
A new approach pioneered by Andrei Rogers and colleagues also traces low fertility, aging populations

6 **Fueling Europe in the Future**
Wolfgang Sassin warns against postponing the restructuring of Western Europe's energy system

10 **Recession: Ten More Years to Go?**
Cesare Marchetti's cycle studies predict next boom, suggest what to do in the meantime

14 **News from the Institute**
Profile of new NMO, American Academy of Arts and Sciences

16 **Guest's Corner**
Austrian Minister of Science and Research Dr. Hertha Firnberg



Migration and Settlement

Andrei Rogers discusses the IIASA investigation of migration and population distribution patterns in the countries of the Institute's member organizations, which has become the largest study of internal migration ever undertaken anywhere. The study also highlighted the low fertility levels and aging populations in these countries.

The "population problem" has two facets: growth (positive or negative) and spatial distribution. We believe that where people choose to live presents issues and problems that are potentially as serious as those posed by how many children they choose to have. The question of numbers has received wide analysis, but internal migration and its consequences for the growth and decline of areas within a country has, until recently, been accorded much less attention. IIASA's study is the first of its kind. That, of course, means that a great deal has been learned about population redistribution patterns and even more about analytical—conceptual problems in comparative migration analysis.

One of our principal purposes in starting the project was to convince demographers and other professionals

"Multistate" Approaches. A fundamental new departure bearing on life table applications is the result of work by Andrei Rogers and associates, who have brought many demographic analyses under a single approach. In this approach, individuals are permitted to move freely within a matrix, among several states or conditions. Transitions can occur from any state to any other state and in either direction. A ready example is the geographic one, where movement can literally be among all "states", but, statistically speaking, movement can be as readily from employment to unemployment or from marriage to nonmarriage. The highly sophisticated mathematical equipment already developed in the matrix field greatly expands the potential for analysis of these events.

Many classic demographic problems, including much life table work, are special applications of this broader approach. ... Thus the new methods make traditional analyses easier, permit more realistic assumptions, enlarge the scope of what can be investigated, and yield insights not previously attainable.

John A. Ross

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OPTIONS

ISSN 0252-9572

is produced quarterly by the Office of Communications, IIASA. Material from *Options* may be freely used and reproduced with acknowledgment to the International Institute for Applied Systems Analysis. Please send tearsheets of any printed reference to the Office of Communications, IIASA, A-2361 Laxenburg, Austria. Telephone 02236 71521; telex 079137.

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Printed in Austria

concerned with population matters that it is important to take migration and spatial distribution into account when analyzing demographic structures. Using new theories and methods of multiregional (multistate) demography (*see boxes*), we were able to demonstrate how this could be done.

The principal argument of the multiregional perspective is that it is not enough simply to examine a single regional population when studying developmental dynamics. One must simultaneously also consider the several other regional populations that are interacting with it. This idea is not new; it has long been taken for granted by economists that to investigate the dynamics or evolution of one sector of the economy, one must also look at the other interdependent sectors affecting and being affected by that sector. This notion underlies the perspective of input–output analysis, for example.

Populations increase because of births and in-migration and decrease through deaths and out-migration. If more people leave an area than come in, there is negative net migration; the opposite situation gives rise to a positive net migration. The point of the multiregional perspective is that there is no such person as a net migrant. An out-migrant from one region becomes an in-migrant to another, creating a link between two regional populations.

The idea is simple; its implementation is less so. But the kinds of insights and understandings that it gives to population dynamics are very important. Only in this way can one define probabilities of migration and associate them with explanatory models. This has important implications, particularly when population patterns change as they have been changing in most developed countries.

Economically depressed regions, rapidly growing areas, deteriorating city centers – all exhibit some of the effects of internal migration and reflect problems that government officials, from the local to the national level, are having to cope with and manage. Services must be provided, which is one reason demographers have always been asked to make projections. But different services are necessary for different age groups: retirement communities, for example, do not need elementary schools but they do need sophisticated medical service centers.

An important function of a working life table is to quantify movements into and out of the labor force. ... A careful reevaluation of the conventional worklife model has revealed some conceptual and technical deficiencies which have led to questionable estimates for certain population groups. For this reason, the staff of the Bureau of Labor Statistics has undertaken a study of alternative worklife estimation procedures. The new ... working life tables for the United States are the result of one such alternative method, known as the 'increment–decrement' or 'multistate' life table model. ... In any multistate life table, members of the stationary population are assumed to move back and forth according to prevailing age-specific probabilities of transition... Andrei Rogers of the International Institute for Applied Systems Analysis in Laxenburg, Austria was one of the first to exploit this technique. He expanded the basic life table to describe a multiregional system in which both migration and mortality patterns differed by location. Working alone and with Frans Willekens and others, he developed a number of interesting applications of the model, both in marital and labor force studies.

Shirley J. Smith

Shirley J. Smith, *Tables of Working Life*, Bulletin 2135, US Department of Labor Bureau of Labor Statistics, Washington, DC. November 1982, pp. 4, 1, 9.

The Comparative Migration and Settlement Study

IIASA's comparative study on migration and settlement began with two basic components: methods and computer programs for multiregional demographic analysis and collaborators in the seventeen NMO countries. Our goal was a case study of each country to be

Professor Andrei Rogers has directed IIASA's population research since he joined the Institute in 1975 from Northwestern University, Illinois, USA.

carried out by a scholar from that country. Each follows a common framework and the data, collected by the authors, were processed using the computer programs at IIASA. In order to interpret these results, the twenty-six scholars involved had to be trained in the methodology by those at IIASA familiar with the theory. The success of this training led us to offer short courses at IIASA and in Mexico and to plan for one in Bulgaria this year. We are now beginning to see the impacts of this expanding network of international scholars as articles are published in several languages, not only discussing the IIASA migration work but also using multiregional demographic analysis and our computer programs in other fields of population studies.

Another result of this project is the extensive data bank that we have collected for the seventeen countries: data that in some cases were previously unavailable to international scholars, such as data on multiregional population dynamics in the Soviet Union. Many organizations, among them the Population Division of the United Nations, have requested copies of our data bank along with the computer programs.

All seventeen case studies have been published (*see box*) and, together with six reports on the study's models, methods, and computer programs, form a three-box set. Each case study presents an analysis of regional birth, death, and migration rates, describes the present situation with projections to the year 2000, and summarizes national population policies. All seventeen reports include extensive appendices containing the data used and the numerical results obtained. A comparative analysis is now being written and will be published in the Wiley–IIASA International Series on Applied Systems Analysis, entitled *Migration and Settlement: A Multiregional Comparative Study*.

International comparisons are difficult to make because ways of collecting data (censuses or registers) and sizes of regions used in each analysis vary. Although we were able to make rough adjustments to overcome these handicaps, we found that a comparison of regions within a country was far more informative than one between countries.

Migration

Migration in all of the seventeen countries studied is no longer the massive rural-to-urban movement that is still under way in the Third World. Large cities are no longer gaining in population as much as before, and indeed many of the largest metropolitan areas had fewer people at the beginning of the 1980s than a decade earlier. Examples of this pattern are Rotterdam in the Netherlands, New York in the USA, Hamburg in the Federal Republic of Germany (FRG), and Leipzig-Halle in the German Democratic Republic (GDR). Paris, London, Stockholm, and Amsterdam all had more out-migrants than in-migrants in the 1970s, while smaller urban settlements grew through migration.

After examining more than 800 age-specific profiles, we have found striking similarities in the age patterns of migrants around the world. The peak for migration is almost always between the ages of 18 and 24, when people leave their parents' homes to start their own families, to report for military service, to attend institutions of higher education, or to take their first jobs. Along with this peak is an almost equally high rise in the first age groups – infants moving with their parents. A third increase often appears at the end of the profile in the 60-and-over age groups because of retirement migration.

Migration profiles show remarkably persistent regularities, although the areas under the curves may vary. Because of this regularity, we were able to develop techniques for inferring migration flows and mobility probabilities, estimates that are particularly useful in studying migration patterns and making regional demographic projections in countries that lack data (such as many African nations).

Migration and Settlement Series

1 United Kingdom
Philip Rees
2 Finland
Kalevi Rikkinen
3 Sweden
Åke Andersson and Ingvar Holmberg
4 German Democratic Republic
Gerhard Mohs
5 Netherlands
Paul Drewe
6 Canada
Marc Termote
7 Hungary
Klára Bies and Kálmán Tekse
8 Soviet Union
Svetlana Soboleva
9 Federal Republic of Germany
Reinhold Koch and Hans-Peter Gatzweiler
10 Austria
Michael Sauberer
11 Poland
Kazimierz Dziewoński and Piotr Korcelli
12 Bulgaria
Dimiter Philipov
13 Japan
Zenji Nanjo, Tatsuhiko Kawashima, and Toshio Kuroda
14 United States
Larry Long and William Frey
15 France
Jacques Ledent with Daniel Courgeau
16 Czechoslovakia
Karel Kühnl
17 Italy
Domenico Campisi, Agostino La Bella, and Giovanni Rabino

Using statistics of life expectancy at birth – which do still vary between the regions of a country – multiregional demography can also tell us where the remaining lifetime of individuals is expected to be spent. For example, let us take two people from the FRG, one born in Hamburg and one born in Schleswig-Holstein. With current mortality–migration trends, the person from Schleswig-Holstein can expect to live 33.1 years of his life in his native region, 9.0 years in Lower Saxony, 8.6 years in North Rhine-Westphalia, and the rest of his life divided among the other regions of the country. The person born in Hamburg can expect to live 23.8 years in Hamburg, 13.1 in Schleswig-Holstein, 12.3 in North Rhine-Westphalia, and so on. Such analyses were made for all regions of each of the seventeen countries and can be found in each individual national case study report.

Projections to the year 2000 show the following regions gaining substantially in their share of total national population: British Columbia in Canada, the Vorarlberg province of Austria, Berlin in the GDR, the Kanto region in Japan, the western states of the USA, and the Central Asian republics of the USSR. Those with declining shares of national populations include Vienna in Austria, Quebec in Canada, the western region of the Netherlands, the north of France, and the Kyushu region in Japan.

Age Structure and Fertility

The study showed that the proportions in the various age groups differed in the seventeen national populations, though in each country roughly 60 percent of the population was between the ages of 15 and 64. Again it was found that the largest differences were between regions within a country, rather than between countries. For example, the proportion of those under 20 years of age in the Austrian province of Vorarlberg is almost twice that of the province of Vienna; in the Latvian Republic of the USSR, almost 30 percent of the population is below the age of 20, while over half the population of the Tadzhik Republic is in this age group.

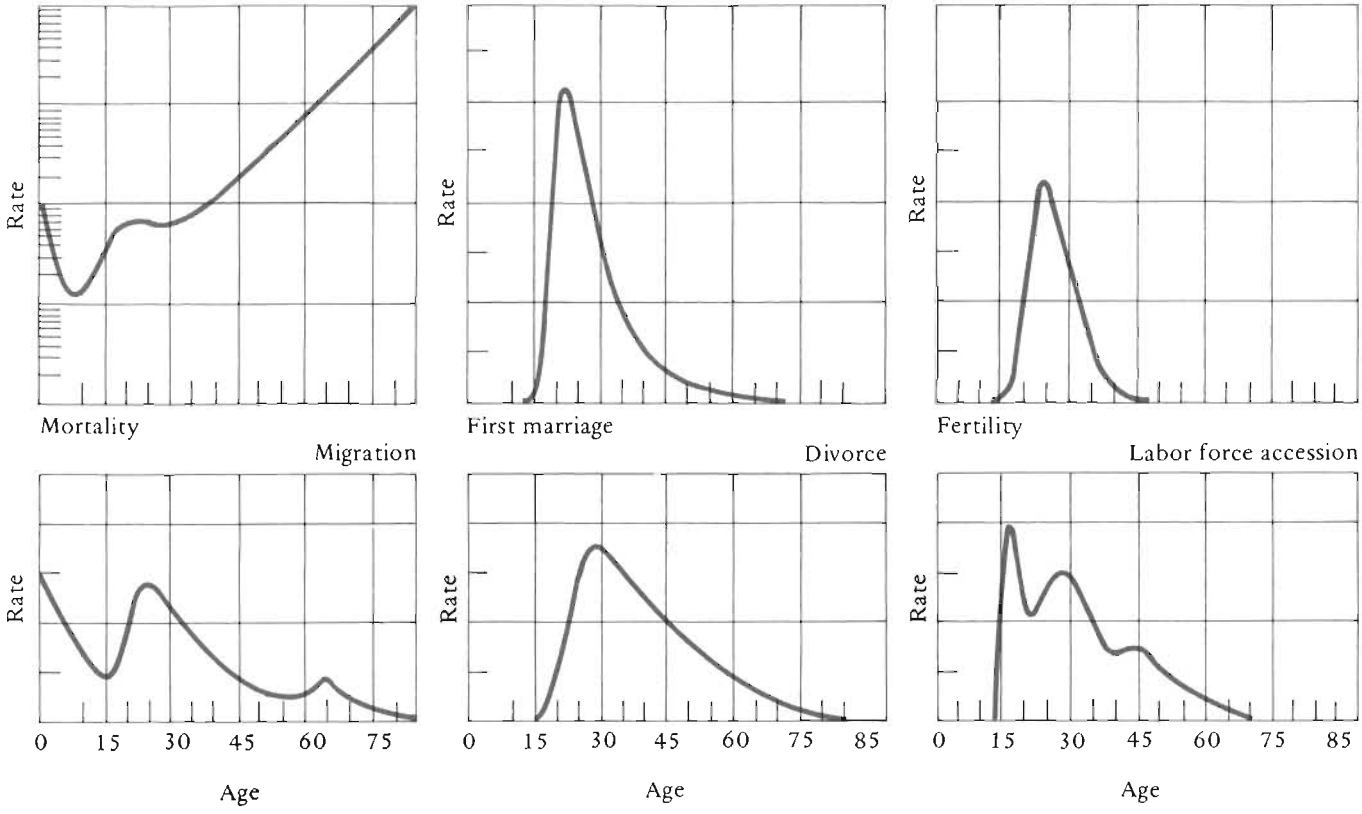
Breakdowns by age and sex give us a look into the future, since the number of women of childbearing age (or the number there will be) reflects how many children are likely to be born. We found again that the differences between regions in a country are more striking than the differences between the countries in the study. The Soviet Union, because of the higher proportion of younger women in the Central Asian republics, has the greatest variations between regions in both fertility levels and age patterns of fertility. Poland, Italy, and Canada also show regional disparities – the gross reproduction rate in Newfoundland, Canada is 73 percent higher than in Quebec. Women in the countries of Eastern Europe apparently have their families at younger ages; there is high fertility among age groups 15–19 and 20–24 in Bulgaria, Czechoslovakia, Hungary, and the German Democratic Republic. Fertility in Japan is concentrated almost entirely in the age group 25–29, with Italy, the Netherlands, and Sweden also showing their highest fertility in this age range. Fertility between the ages of 20 and 29 is fairly evenly spread in the FRG, Finland, France, and the United Kingdom.

A fertility level of 2.1 is necessary to replace one generation with another. Every existing male and female has to be replaced by a baby boy and a baby girl. The 0.1 is necessary because not all girls reach childbearing age and because 105 boys are born for every 100 girls. Thirteen of the seventeen countries have fertility levels below 2.1. Four – Bulgaria, Czechoslovakia, Poland, and the Soviet Union – have levels

Population data for the countries of IIASA's seventeen NMOs.

Country (reference year)	Gross reproduction rate*			Percentage of population aged 65 and over			Total population (in millions)	
		Regional			Regional			
	National	Lowest	Highest	National	Lowest	Highest	1980	2000
Austria (1971)	1.09	0.82	1.31	14.2	9.5	20.0	7.6	8.0
Bulgaria (1975)	1.10	0.96	1.22	10.9	7.7	16.0	9.0	9.6
Canada (1971)	1.23	1.10	1.90	7.9	6.0	10.9	23.0	28.6
Czechoslovakia (1975)	1.21	1.13	1.39	12.1	9.1	15.7	15.4	17.2
Federal Republic of Germany (1974)	0.73	0.58	0.81	14.3	12.9	22.2	61.3	57.6
Finland (1974)	0.79	0.73	0.96	10.3	7.3	13.4	4.8	4.8
France (1975)	0.94	0.83	1.12	14.2	12.1	17.7	53.3	55.7
German Democratic Republic (1975)	0.76	0.74	0.80	16.3	13.5	17.9	16.7	16.0
Hungary (1974)	1.14	0.99	1.36	12.3	11.2	13.7	10.8	11.3
Italy (1978)	0.91	0.76	1.17	12.8	10.8	14.0	57.0	59.5
Japan (1970)	1.05	1.01	1.15	7.1	5.8	9.9	116.4	129.4
Netherlands (1974)	0.87	0.81	0.98	10.6	8.2	13.7	13.9	15.1
Poland (1977)	1.10	0.81	1.41	9.9	6.3	11.5	35.7	40.7
Sweden (1974)	0.92	0.86	0.97	14.8	12.8	16.8	8.3	8.2
Union of Soviet Socialist Republics (1974)	1.33	0.97	1.92	10.0	6.3	12.0	266.0	311.6
United Kingdom (1970)	1.18	1.11	1.26	12.9	11.0	14.9	56.5	61.8
United States (1970)	1.26	1.22	1.30	9.9	8.9	10.6	225.0	270.7

*The gross reproduction rate relates to a population of a single sex (or the sexes taken together) and is roughly one-half of the total fertility rate.



barely above 2.1, and we expect that all four will drop below that figure during this decade.

We believe these low fertility levels will continue. If 10 percent of the women in a country never have children and 20 percent have one child, simple arithmetic shows that 50 percent of the remaining women in the country must have three children in order to replace their generation. We do not see this happening in the future.

Future Research: Aging Populations

At the same time that fertility has declined, people in these countries are also living longer. In most of the seventeen countries, the proportion of elderly – those 65 years of age or older – increased during the last decade owing to improved health care and living conditions. In the GDR, France, and Sweden, more than 5 percent of the population is 75 years old or older.

The FRG and Austria are not far behind. These five countries showed the highest fractions of people over 65 years of age and the oldest mean ages in the study. Hungary and the UK follow closely. The "youngest" countries were Japan and Canada, but by 1980 sharp declines in fertility also gave these nations "graying" populations.

Nevertheless a few regions, mainly those centered on large cities, may expect a decline in the number and proportion of elderly people. The largest decline will probably occur in West Berlin: between 1974 and 2000, the number of people over 65 years of age is expected to decrease by 55 percent and the proportion of elderly will drop from 22 percent to 14 percent of the population. While West Berlin's elderly population will halve, Vienna's will drop 35 percent. In 1971, one out of every five persons in Vienna was older than 65; by the year 2000, it is expected to be one out of every seven.

Despite the decline in aging populations in a few single regions, the Migration and Settlement Study clearly identified an overall aging of these national populations, a consequence of their low – mostly below replacement value – fertility levels. We are already seeing how these factors affect social policies. Social security systems now have fewer workers supporting a larger number of pensioners. Demands for health care and income maintenance are increasing to unprecedented levels and governments are having to provide such services during a worldwide recession. Rising divorce rates and higher female participation in the labor force are creating changed lifestyles that complicate the provision of family care.

We are undertaking a new project at IIASA to examine these population issues and alternative policies to deal with them. Our past methodological work will form an important part of these studies.

The mathematical apparatus developed to study migration between regions is also a useful tool for examining movements between non-geographic "states". Divorce, for instance, can be viewed as a move from the state of being married to the state of being divorced. Unemployment can be seen as moving from the state of being employed to the state of being unemployed. Migration is just one type of transition. We have found that there are similar age regularities for other transitions. We will therefore investigate changing patterns of behavior and their socioeconomic consequences using the mathematics of multiregional (multistate) demography developed at IIASA.

Fueling Europe in the Future

An energy policy study carried out by IIASA for the EC Commission found over-optimistic expectations of economic growth, the availability of energy imports, and conservation potential. Extending the insights of IIASA's global study *Energy in a Finite World*, **Wolfgang Sassin** warns against postponing the necessary restructuring of Western Europe's energy system.

Nearly ten years after the quadrupling of crude oil prices on the world market, the countries of the European Communities still rely on oil, 80 percent of it imported, to meet around half of all their energy needs.

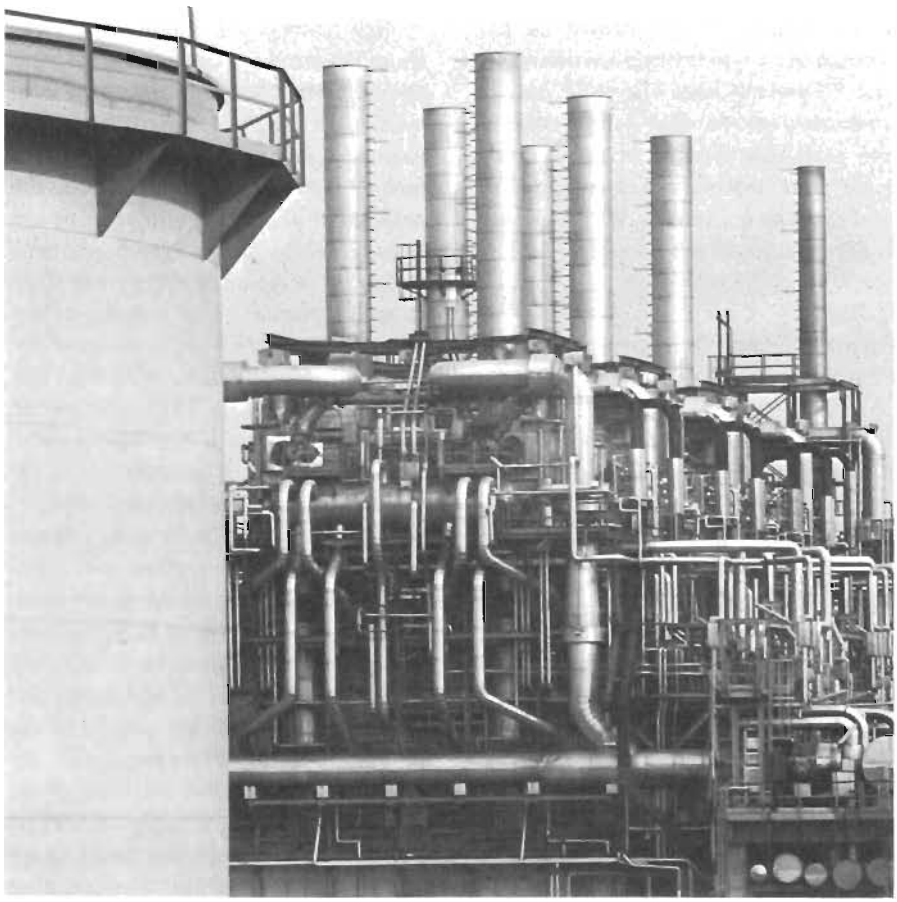
Different EC countries responded to the oil crisis in different ways. For the United Kingdom, it was the stimulus to the rapid development of its North Sea oil and gas resources. Imported oil now accounts for less than a quarter of the UK's energy consumption. France and Italy are both poor in all fossil fuel resources (coal, oil, and gas). France embarked in the 1970s on Europe's largest nuclear power program, whereas Italy still imports oil to meet some two-thirds of its energy requirements. The Federal Republic of Germany began to substitute natural gas for imported oil, and the Netherlands greatly increased its exports of natural gas and petroleum products.

Over the past two years oil prices have declined in real terms owing to inflation and because the US dollar, in which prices are fixed, has fallen on world money markets. The recent cut in OPEC's benchmark price has afforded the EC countries some short-term relief. But continued reliance on imported oil merely postpones – and makes more difficult – the shift to other resources that is ultimately inevitable. North Sea oil and gas are moderate resources in comparison with the EC's energy needs. The earth's fossil fuel resources, although abundant, are nevertheless a finite one-time endowment. Known reserves of easily accessible conventional oil could be approaching exhaustion in thirty years – just one generation.

According to Dr. Wolfgang Sassin, the physicist from the Federal Republic of Germany who directed an energy policy study at IIASA for the Commission of the European Communities: "In order to meet energy demand in a globally consistent way, the EC will have to provide for reduced economic growth, vigorous conservation efforts, and the development of *all* domestic energy resources: coal, oil, gas, renewable resources, and nuclear energy. These are not alternatives. Supply constraints will to a large extent dictate the EC's energy balance, almost irrespective of price or cost relations.

"Ultimately – but beyond 2030, IIASA's global study found – the transition must be made worldwide to a sustainable energy system based mainly on renewable resources, or on solar power, nuclear fusion, or advanced fission reactors, all of which use nondepletable resources. Unlike the change last century from renewable to more efficient and versatile exhaustible energy sources, this transition will probably have to be made against a background of rising rather than falling energy production costs. Thus traditional free market mechanisms alone cannot be relied on to stimulate the high risk technological innovation that will be needed to exploit more expensive alternative resources. Furthermore, the less rewarding the basis on which the old infrastructure operates, the greater is the burden of introducing a new and even less rewarding energy system. This means that the transition to a sustainable energy system is likely to become more difficult the longer it is postponed. In other words, time is limited.

"Because of the vastness and complexity of the present energy system, lead times for the introduction of basic energy technologies may range from



Martin Schobel

Dr. Wolfgang Sassin

thirty to fifty years," Dr. Sassin continues. "A detailed analysis of potential long-term developments is therefore indispensable in assessing technological R&D strategies. The analysis should also be globally comprehensive, since the responses of other countries to the increasing scarcity of energy resources will have implications for the viability of the EC's import plans. Several countries, for example, might be planning to import the same barrel of oil."

"Dirty" Hydrocarbons

For the next half century fossil fuel resources will continue to dominate the world's energy supply, and global consumption of both oil and gas will probably continue to increase throughout this period. "But," Dr. Sassin notes, "these two resources will become progressively costlier to produce as deep formations of natural gas and polar and deep offshore deposits of oil are exploited, and conventional sources will need to be complemented with 'dirtier' hydrocarbons such as oil shales and tar sands that are less accessible and more expensive to extract."

There is no contradiction here with the present surplus of oil on the world market. "If we have to pay a high price for the oil," Dr. Sassin remarks, "we cannot speak of an oil glut. It is too expensive a commodity. The IIASA study not only considered the physical supply potential, but also took into account the fact that buying this oil places a strain on the economy and requires compensatory exports. This in turn needs more energy and raw materials, and constrains the availability of capital for restructuring the economy.

"We envisage a trend over the next few decades away from the present high level of oil imports into Western Europe toward imports of coal and natural gas, from Siberia, Eastern Europe, or North America," Dr. Sassin states. "The technical problems associated with the intercontinental transportation of gas through high pressure pipelines or by LNG (liquefied natural gas) tankers are not insurmountable." But such projects pose political problems too, as shown by the recent dispute over the supply of equipment for a new natural gas pipeline from the USSR to Western Europe, which highlighted the worldwide resource flows and the international interdependence that characterize the global energy system.

Energy as a Factor of Production

"Where the recent IIASA analysis for the EC Commission differs from previous studies of Europe's energy options is in treating energy as a factor of production as well as capital and labor," explains Dr. Sassin. "The underlying principle in the analysis was to postulate equilibrium conditions for the substitution of capital and labor for energy; that is, to find the best possible allocation of all three resources on the basis of their respective market prices. This links the value of energy to the productivity of capital and labor.

"Substitutions that make better use of energy might variously be termed conservation, efficiency improvements, or productivity increases. What they have in common is that they all involve not curtailing services but replacing part of the energy needed to perform a given service with something else. For example, investing in insulating a house diverts capital but saves energy. Tuning an engine, an investment of labor, reduces its fuel consumption. Energy may be saved simply by ingenuity: by designing a more efficient engine, or by developing a new steelmaking process for example. Thus resources of capital, labor, and know-how can be rearranged to conserve energy, and by investing these resources appropriately — in education, R&D, capital equipment, exploratory drilling — the stock of resources that can be turned to use can be increased and the economy can grow."

The IIASA study for the European Communities used computer models to simulate and balance energy demand and supply over the five decades of the study period, and to examine the long-term macroeconomic implications of alternative energy supply scenarios. Scenarios, Dr. Sassin stresses, are neither predictions of what will happen nor prescriptions of what should happen, but comprehensive and internally consistent synopses of possible evolutions. The study did not set out to provide a blueprint for the EC's optimal energy strategy. It concentrates on the technical and economic aspects of energy supply, which means incorporating several implicit assumptions. Essentially it takes for granted a "business-as-usual" future and assumes a functioning world trade in fossil fuels at prices, except for oil, not greatly higher than production cost levels.

Projecting Energy Demand and Supply

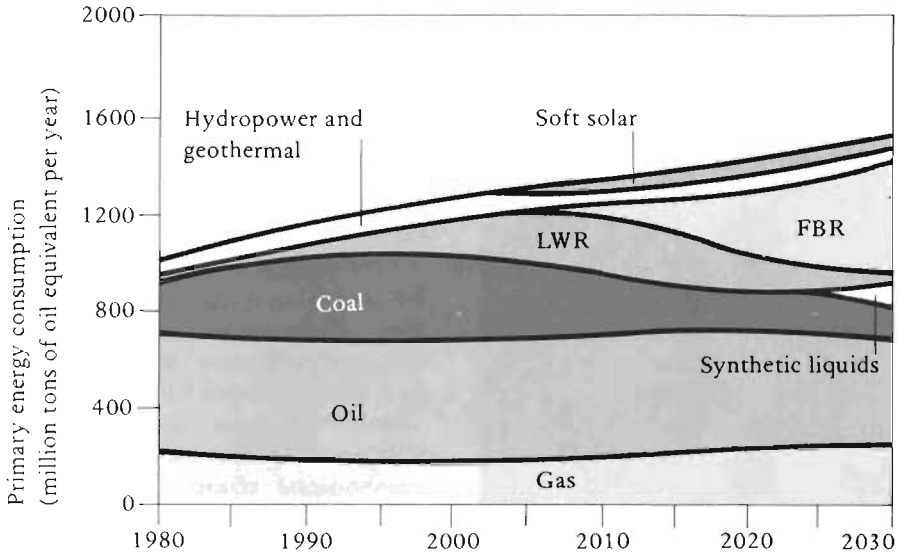
Population growth, economic growth, technological change, and structural evolution are the four principal determinants of energy demand. To project energy demand, future population growth could be estimated, but assumptions had to be made about labor force participation and labor productivity and the evolution of the various sectors of the EC economy. These assumptions can only be based on informed judgments: the analysis can never be value-free. The EC economy was disaggregated in the study into the production of goods, freight transportation, passenger transportation, households, and the service sector, and then these categories were further subdivided. Energy efficiencies, growth rates, and shifts between sectors were projected. Assumptions were then made

about energy-related details of "lifestyles": heating requirements, car ownership, distances traveled by private and public transport, use of electrical appliances, and so on.

The next stage was to assess the possibilities for providing the amount of final energy required using available resources and technologies for production and conversion. (A final energy carrier is gasoline or electricity, for example; primary energy is the fuel we take out of the ground, such as crude oil or coal). The amount of primary energy needed to supply this much final energy depends on the efficiency of the energy supply system. Conversion losses in refineries and power stations and distribution losses presently amount to a large proportion of primary energy consumed.

"The demand for liquid fuels for transportation and the chemical industry will outstrip the supply potential of crude-oil-based products," Dr. Sassin states. "For this reason coal liquefaction to produce synthetic fuels, or 'synfuels', on a large scale from the year 2000 was included in the study. A moderate growth in nuclear power was projected: advanced reactors were assumed to replace present reactor designs well within the time period of the study. Renewable resources such as hydroelectric power, geothermal power, biomass, and wind power were also considered, but are assumed not to contribute more than six percent of the supply before 2030, because of their expense and the long lead times involved. Far from being a reason for neglecting R&D in these areas, this makes it all the more important to press ahead with their development."

A macroeconomic model was used to cross-check the effects of various energy supply strategies on the economic environment in Europe. Dr. Sassin explains the results: "We found that the level of energy conservation that other studies have assumed seems to be grossly over-optimistic and to neglect economic considerations. This means that with less energy conservation than we might technologically be able to achieve, we have higher import requirements. This raises the question of the general trade patterns of the EC with the rest of the world, and at that level one can only introduce general assumptions. We ruled out strategies for the EC that exacerbated the energy problem elsewhere in the world."



Primary energy balance in IIASA's low growth scenario for the EC. LWR, light water reactor; FBR, fast breeder reactor.

Conserving energy by substituting highly productive capital or labor can cost up to several times the economic value of the energy conserved, as well as being time consuming, Dr. Sassin found. "As long as capital and labor costs grow faster than energy costs in certain sectors, it makes more sense to conserve these production factors and substitute for them. Conservation should mainly be a process justified by general economic principles.

"The study found previous investigations of the European energy future to be optimistic with regard to economic growth rates and import opportunities as well as conservation potential. In IIASA's macroeconomically balanced scenarios for the EC, a substantially lower economic growth rate is projected, declining steadily over time though remaining positive, and it is against this background that the EC's energy system will have to be restructured."

Between Scylla and Charybdis

The range of technological choices open to the EC in a medium- to long-term future of low economic growth was explored by developing two extreme versions – in practice some intermediate evolution would be preferable – of a macroeconomically balanced demand and supply scenario. The first is characterized by the assumption of favorable capital costs for nuclear energy; the second presupposes higher investment costs for nuclear energy, thus favoring the use of coal for generating electricity. The GDP annual growth rates in the two scenarios are almost identical, declining from an average of 2.2 percent (1985–2000) to 1.1 percent (2015–2030), but resources were found to be allocated quite differently by the models.

Coal consumption drops off markedly by 2000–2010 in the nuclear scenario; in effect coal is used for generating electricity only until advanced nuclear reactors such as fast breeders can take over. In the longer term, however, coal consumption increases again owing to its use in the production of synfuels. In the coal scenario, the consumption of coal grows more steadily, permitting a more gradual deployment of advanced nuclear reactors. The use of uranium is actually greater in the coal scenario because of this delay in commissioning advanced reactors (which make much more efficient use of uranium) and the concomitant greater utilization of light water reactors. In fact, the world's uranium resources, which are in energy terms only the rough equivalent of global oil re-

serves, are almost exhausted in the scenario.

The coal scenario and the nuclear scenario were assessed for compliance with the two supposed EC policy goals designed to limit vulnerability to supply disruptions: a limit of 50 percent on the proportion of total primary energy imported and a limit of 30 percent on the share of any single primary energy carrier. It was found that in 2030 in the coal scenario, imports account for between 40 percent and 61 percent, and coal comprises 35 percent, of the primary energy supplied. In the nuclear scenario imports represent between 28 percent and 33 percent and nuclear energy accounts for 34 percent of supply. The level of imports depends on whether the uranium consumed is assumed to be indigenously produced or imported.

"The choice of emphasis between coal and nuclear energy is a vital one, requiring policy decisions and infrastructural adjustments well in advance of implementation. Further supply options such as centralized solar energy, nuclear fusion, or liquefied hydrogen will not become widely available within the time horizon of the study, we found.

"In both the coal and the nuclear cases," Dr. Sassin continues, "the energy sector charges against the rest of the economy. In economic terms it makes little difference whether energy is supplied by way of increased imports, resulting in trade deficits, or through the increased domestic investment necessary to build an advanced nuclear infrastructure. Economic growth is impeded roughly equally in the two scenarios if we ignore the multiplier and accelerator effects of domestic investment.

"Even the limited room for maneuver that emerges from the scenarios is based on optimistic assumptions about the availability and prices of energy supplies and will no doubt be reduced further by sociopolitical and institutional factors. The use of fossil fuels will be constrained by both the environmental disruption caused by their extraction and combustion and the limits to society's tolerance of changes in natural systems, and nuclear energy by difficulties with radioactive waste disposal."

Projected final energy demand characteristics for the EC in 2030.

	1975 (base year)	2030
Population (millions)	258	290
GDP per capita (thousand US(1975) dollars)	5.25	12.4
Final energy per capita (kilowatts)	3.5	5.7
Electricity per capita (kilowatts)	0.4	1.1
Final energy per unit GDP (watts per US (1975) dollar)	0.67	0.46
Final energy per unit value added in the manufacturing sector (watts per US (1975) dollar)	1.00	0.74
Final energy per ton-kilometer freight (kilowatt-hours thermal)	0.552	0.552
Final energy per passenger-kilometer (kilowatt-hours thermal)	0.424	0.335
Final energy per dwelling (thousand kilowatt-hours)	25.5	31.9
Final energy per 100 square meters floor area in the service sector (thousand kilowatt-hours)	37.2	34.6

The Broader Challenge

The study raised the crucial question of the extent to which the EC's economic evolution might be impeded by the energy problem. Hundreds of billions of dollars, a large fraction of the world's aggregate GDP, would have to be invested by the industrialized countries in the resource-rich countries to develop their great fossil-fuel resource basins. If the actual deployment of energy technologies falls short of the levels projected in the scenarios, the EC's room for maneuver will be even further reduced. Most European countries have cut back their original nuclear power programs, whether through declining energy demand in the past years of recession or owing to public opposition to the commissioning of new reactors. It is evident that the nuclear industry growth projected for the 1980s and 1990s was overestimated. Unless capital or labor productivity can be further increased, then either the import dependence must rise or economic aspirations must be further reduced.

Developments since 1975, the base year for the study calculations, bear little promise for global free trade in coal, oil, and gas: other exporters have followed OPEC's lead by limiting their oil and gas production in their own long-term national interests and seeking to keep prices high. This indicates a need for the EC countries to develop a degree of technological flexibility so as to be able to respond to changes on international energy markets. "The study," says Dr. Sassin, "was intended to define not the most probable future development, but the utmost that could feasibly be achieved with the world's energy resources, capital, manpower, and know-how. It should always be borne in mind that much more than technological development is required to make an option viable; political developments will doubtless modify the supply options open to the EC countries.

"Energy consumption is not an end in itself, but a means to social ends, and a technoeconomic study is not in itself a valid basis for decisions. The debate about energy policy is a very broad one, raising not only technical and economic but geopolitical, social, and even ethical issues. The energy problem must be seen as part of an even greater challenge facing the EC countries over a broad area of public policy, and energy strategy should be part of the flexible and rational response demanded in technology, in economic development, in international cooperation, and in the way of life of their citizens."

Derek Delves

Further details of the energy study for the EC will be available from IIASA in *Fueling Europe in the Future. The Long-Term Energy Problem in the EC Countries: Alternative R&D Strategies* (forthcoming), by Wolfgang Sassin, Alois Hölzl, Hans-Holger Rogner, and Leo Schrattenholzer.

Recession: Ten More Years to Go?

Cesare Marchetti argues, in his usual provocative manner, that the current recession may well last another ten years, based on his application of Darwinian insights to economic analysis.

That the present recession is a really serious one, and that it has many aspects in common with the recession at the end of the 1920s, more and more people have come to acknowledge. But opinion varies on its likely depth and duration, and the underlying logic is weak. It is this logic that I shall try to buttress and clarify.

The first tangible sign of a recession is that people start losing their jobs beyond the level of two or three percent of the work force; this level is considered physiological, and can be in good part attributed to the mobility of the work force. I recently made a study of the development of the automobile industry and I shall use this example to illustrate how people lose jobs.

A common characteristic between my analyses of economic and social structures is that they are based on physical quantities and not on value. The mental image I have in exploring the time dynamics of these quantities is the Darwinian competition between species, whose mathematical counterpart is Volterra's ecological equations. This image is perfectly captured by the statement of Heraclitus that competition is the father of everything, and the king too. In modern terms it is the creative and regulatory force.

Coming back to cars, I formally assumed that they were an animal species expanding into various niches territorially coinciding with countries, such as the USA, France, or Italy. The expansion of a species in a habitat, whether bacteria or foxes, is best described by a logistic equation. The precision of the fit with the historical data for cars is just amazing. To give one example, the deviation from the fit for the car population in Italy over twenty years was less than one percent, as shown in the diagram.

These logistic equations have only three parameters, or three knobs to turn to fit them to the data. One fixes the position in time of the phenomenon; the second gives the dynamics of the process; and the third is the size of the niche, that is, the maximum number of animals it can support. If the quality of the data is high, as in the case of car populations, and there are no hiccups or uncertainties, then the three parameters can be directly calculated from the data without requiring external information.

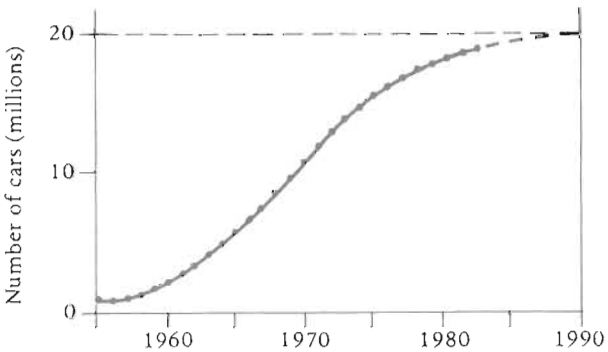
This last fact is extremely important because *it permits us to calculate the final population of objects intrinsically from the dynamics of their market penetration*. And it cuts the Gordian knot of econometric hypotheses, in which the result usually depends on the investigator's opinions or, more often, on those of the sponsor. The justification for the use of such a technique is that it applies to all sorts of competition and expansion behavior. We have in fact a portfolio of about four hundred cases of economic and social behavior analyzed in this way.

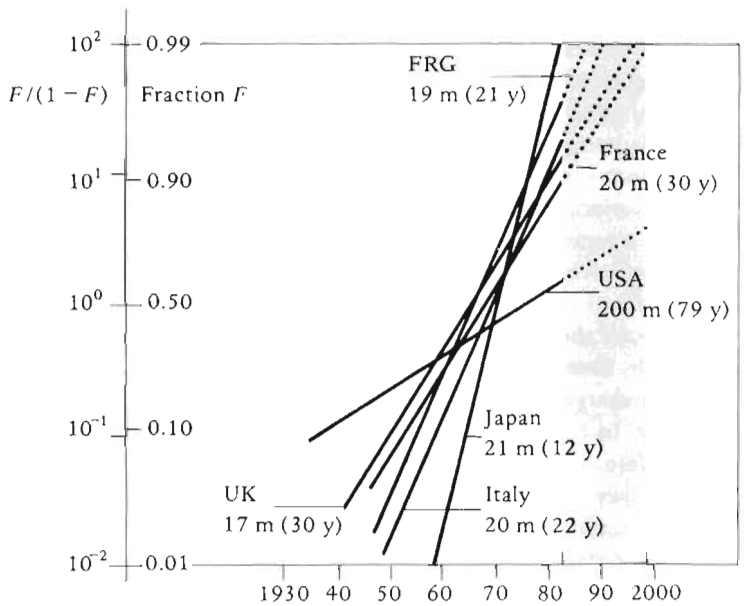
Darwinian Competition

In the case of the car, a saturation level for the car population of each country, which curiously is not directly related to its population or wealth or area or the total length of its roads, can then be determined. Second, and more disturbing, it appears that most of the western countries' car markets are already practically saturated (shown in the diagram below: the ordinates have been chosen so as to make the penetration curves appear as straight lines instead of S-curves for a clearer presentation).

Now, what happens when an industry finds that its market is saturated?

(*Below*) Growth of the car population in Italy. (*Right*) Car populations as percentages of saturation levels. The first figure is the saturation population; the second is the time in years for the population to grow from 10 percent to 90 percent of the saturation level.





First, it will notice that it has excess capacity, since everybody has been operating with a business-as-usual philosophy, expecting expansion to continue for ever. To begin with, the capital burden will increase its weight. Second, production will go to satisfying replacement demand, which is basically a fixed demand. Fixed demand would not be so bad except for the overcapacity and the dynamics of salaries, which push total costs up. The only short-term solution is to increase productivity. But increasing productivity with constant production means shedding jobs. For example, Fiat of Italy maintained its car output even with 70,000 fewer people in its work force in the car division, previously around 200,000.

The really curious fact about market saturation is that it *occurs almost worldwide within a short period*, in spite of the fact that the car market began rapid growth in different countries very randomly. But newer markets grew faster to the extent of overcompensating, as in the case of Japan.

The fact that car populations saturate at the same time all over the world means that the usual safety valve of exporting to compensate for sluggish internal markets does not work any more. Or it works the other way, because competition heats up on the international market with dire consequences for old and established enterprises. In spite of all the institutional barriers that the losers will erect, my Darwinian forecast gives Japan half of all the cars produced in the world in the year 1990.

Not only cars but also many other industries that gave rise to the boom of the 1950s and 1960s have gone through the same development and now find themselves in the same predicament, facing saturated markets and overcapacity, with a consequent need to shed personnel. Companies, like people out of work, become cautious spenders and limit their purchases of services. The wave then spreads; the airlines, for instance, also find themselves overequipped, overstaffed, and moving toward bankruptcy worldwide. They are also starting to shed personnel.

I think the picture is clear enough to go on to the next step — the whys, hows, and whens. Why are so many industries saturating the market at the same time, how can we get out of the doldrums, and when will the vital trade winds start blowing again? The problems of the recession in the 1930s stimulated much theoretical work and, in fact, there is a host of theories — which means that the mechanisms are basically not understood. To aid understanding I shall use the results of system studies I did for completely different purposes, such as the car study, which was originally intended for analyzing the intrinsic dynamic of the spread of an innovation. The surprising result is that at a global level the time for a basic innovation to expand from a 10 percent to a 90 percent share of the potential market is usually about fifty years, whether the innovation is margarine, the vacuum cleaner, or the theory of relativity.

Dr. Cesare Marchetti

I am pretty convinced that this is linked to a basic human behavior, which seems to show extreme constancy. A brilliant demonstration of this is given in the bottom part of the diagram on the next page, where the blue lines show the market penetration of different primary energy forms. The *rate* of penetration, expressed in the appropriate parameter in the equation, stays constant to within a fraction of one percent over the whole period.

Now, if many industries happen to be in the doldrums together, with similar time constants, this means they started up more or less together, and the question is why. Here a system study I made of invention and innovation in the western world over the last three centuries comes to our aid.

Invention and Innovation Cycles

The final result of the study is also reported in the bottom part of the diagram, where each pair of black lines represents an invention wave and a corresponding innovation wave. The invention wave describes the conception of new products whose success is later sanctioned by the growth of a new industry. The lines themselves represent the cumulative number of inventions (or innovations) at a certain date, expressed as a percentage of the total number in the wave. The curious fact here is that formally the set of innovations grew as if it were a population filling an empty ecological niche — that of the need of innovations by the "system", just to extend the analogy.

The question now arises, what generates the empty niche? Simple: the death of a former species. If the mental model holds, then the innovation waves should be spaced apart by about fifty years. They are. The distance between their center points — when half of the innovations in the waves have been made — is precisely fifty-four years.

Now a picture begins to emerge: dying industries create the vacuum, the niche, that the new species, the new innovations, fill. The spacing between spurts is dictated by the time it takes for market saturation of the various industries, which puts the time into the fifty year bracket. Because the same period has been necessary to mesh into the daily routine of the physicist a basic innovation such as the general theory of relativity, I propose to give this time an anthropological significance.

The internal dynamic of each of the waves, on the other hand, accelerates, doubling speed roughly every century. I have not yet found any clue to this very regular acceleration, nor to that of car market penetration, where the time needed to penetrate successive markets decreases exponentially with

the date of the beginning of rapid market growth.

The present innovation rush will formally start in 1984 – 10 percent of the basic innovations introduced – and end in 2002 – 90 percent introduced. These innovations are the seeds of the next boom, which will start when they are large enough to influence the whole economy. But let's look now in more detail at the timing.

The fifty-four year interval that holds so steadily for such a long time is an obvious reminder of the Kondratieff cycles. I read again his brilliant papers of the 1920s, and I would say that there has not been much said after him that he himself did not say. I arrived at many of the conclusions Kondratieff had reached following my completely different line of thought and profiting from the extra cycle that has occurred since his time. The situation seems to me now so clear conceptually and quantitatively, so well mapped, as to be beyond doubt.

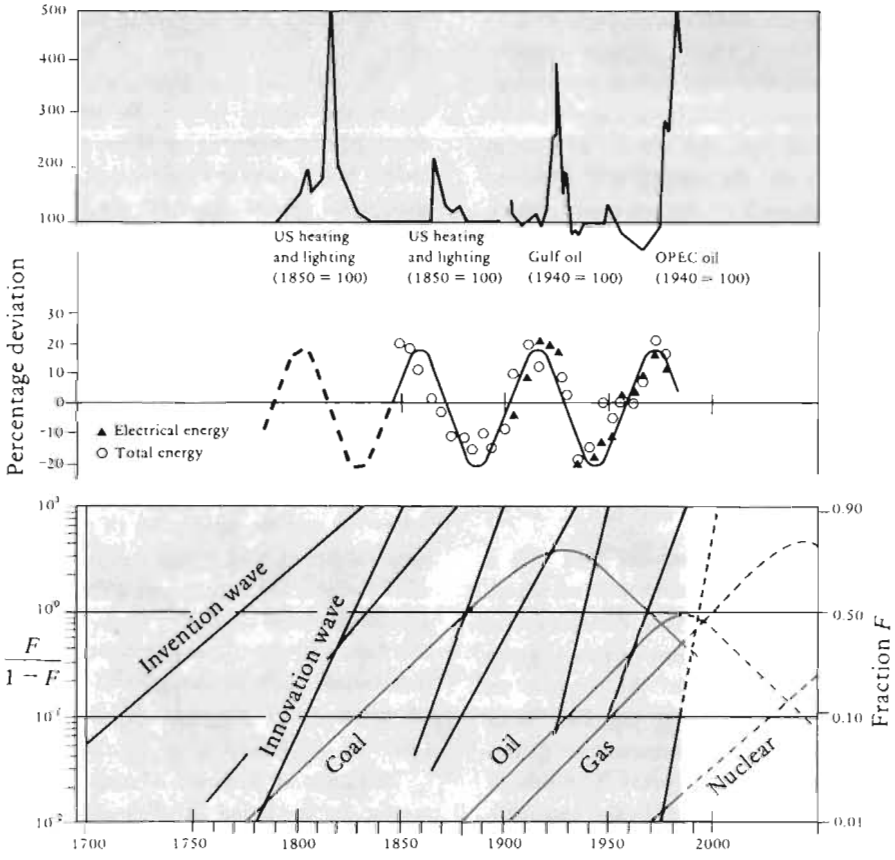
Energy Demand and Energy Substitution

Having to deal, if only indirectly, with economic matters, I have always skipped money as an economic indicator because of its mobility and ambiguity, trying instead to map the processes through their physical manifestations. I have never regretted this choice. To give an example, what about taking the pulse of the economy in physical terms by measuring its demand for energy? The analysis made by Hugh B. Stewart for the US government is shown in the middle part of the diagram, where the oscillations of primary energy demand and electricity consumption about a fundamental exponential growth curve are given as percentage deviations. This metabolic map is in my opinion the best objective measure of what is going on, and the synchroneity of many different features is very striking.

If we look at the upper part of the diagram, energy prices appear basically constant in constant money, with flares about every fifty-four years. These flares occurred, remarkably, four times in coincidence with the peaks of the sinusoid, which basically mark the midpoint of a cycle and the end of the boom period: three times in the past and at the presumed midpoint of the 1980 cycle. Since these peaks have a width of about ten years, the price of energy in general and oil in particular should fall sharply during the next few years – let's say to US$12 per barrel in 1982 dollars.

Financial macro-collapses systematically occur when the sinusoid crosses the zero level; that is, when the speed of fall is maximum. The last time this happened was in 1929; the next is in 1983. *The curve will not start rising again until the 1990s.*

These results give us a fresh and quantitative insight into the cyclic processes of economic activity, and can be used to assess the value of what is being done to deal with the consequences of collapse, and the potential of what could be done.



(*Top part*) Indexed US energy prices. (*Middle part*) Oscillation of US energy demand about its fundamental exponential growth curve. (*Bottom part*) Pairs of invention and innovation waves (black lines) and curves for world primary energy substitution (blue curves).

The Futility of Conventional Measures

The basic cause of weakness, as we saw, is saturation of markets. Can we manage this? Let's take the case of the car. The question boils down to inducing people to own more cars. Apart from the fact that this would only displace the problem by a few years, I am convinced that there is a configurational maximum, the internal logic of which starts to be unveiled.

The first thing governments are called on to do during a recession is to help keep the show running. This is usually done by deficit spending. Deficit spending means that the state takes money from people who have saved it to spread it around for somebody else to spend. This money will never come

back, as is well known. The US government last gave back the principal in 1833. Italy has already spent, in deficit, about 70 percent of all available credit in the nation, which makes reimbursement impossible.

There would be nothing wrong with deficit spending if it were not for two things: the process is self-priming and the recession lasts too long. In other words, the medicine will run out long before the patient is cured. It is perfectly clear that Italy cannot operate over the next ten years as it has done for the last ten, and the USA may reach a similar position only five years from now. And there are ten more years to go before the upturn.

This raises the question of why so much money is available for governments, and for dubious customers in general. On a rough estimate, a trillion dollars in international loans will never be repaid; double this for internal debts. The simplest explanation is that in a phase of boom this money would have gone to industry, but with markets saturating, industries did not really need this much capital. Capital therefore went to customers able to promise to pay high interest rates, even with improbable collateral.

These loans can also be seen as a form of deficit spending. Because the markets were saturating at home, developing countries were given the money to buy goods (otherwise unsaleable) to put a face of proper business formalism on what was actually a give-away in the Marshall Plan style. This mega-lie may strike back destructively on the world banking system when the circular guarantees game is no longer able to hold.

Another form of give-away is to enhance the production of arms, objects to be destroyed, and, *hélas*, to destroy. In this area as well, the temptation is strong and the pressures from the industrial establishment immense. A market of mutually destroying gadgets is ideal as it never saturates. If one adds to that the political necessity of dealing with social dissatisfaction — with an estimate of some 70 million unemployed in western countries in 1988 — the temptation to export the problems via a war becomes strong indeed. The troughs in the diagram have been times of international aggression, culminating, for example, in the Second World War just toward the end of the previous recession (depression) period. The next trough is in the middle 1990s; a war then is something we should certainly find a way to avoid.

How to Lose Least on the Swings

A natural question at this point is how the insights that the analysis gives us into the mechanisms of the recession may help us reach the next boom with a minimum of damage. One point is very clear in the analysis: that the process consists of a transfer of tasks and skills from one class of activities in phase-out configuration to another class in the phase-in stage. The keywords of this transition phase should then be *flexibility* and *adaptability*.

This breaks down into a host of possible initiatives. Instead of giving money (from banks or the state) to the ailing car industry, for instance, it would be much wiser to give the money to the employees themselves, to help them resettle and perhaps start their own businesses. The first procedure can be seen as a freeze, the second as a "fluidifying". Through such a procedure, Olivetti — once a monoculture in the Ivrea area of Italy — has seeded a host of small enterprises which are, in turn, supporting still newer initiatives. The Japanese also follow this policy.

Entrepreneurs will sow the seeds of the upswing during the next twenty years by launching new products — about a hundred according to my estimates. Why not help by giving them money and perhaps even not taxing them? As they will have a lot of technical problems to solve to start their concerns, why not put at their disposal, for nominal fees, the research capabilities of the state? The invention curve of the 1980 wave shows that practically all the inventions going into the next innovation wave have already been made. What's necessary is their development, and this is where state research laboratories, such as the nuclear laboratories, would be appropriate.

During the recession of the 1930s the keynote for state intervention was public works, such as building the European autoroutes. New highways are no longer needed — remember that car markets are saturating — but cities have grown at a hectic pace during the last thirty years, and they tend to be messy beyond description. Improving their comfort and aesthetics is probably one of the most fruitful tasks the public sector can devote itself to this time.

Simple institutional changes could also greatly help. Part-time work, to give one example, would not only keep more people off the breadline but also offer them a lifeline by giving them the chance to move into a new activity. In other words, it increases mobility and creativity.

Deficit spending, as I said, can be seen as a confiscation of money saved and its redistribution for social reasons. In this form it may not last long. But the redistribution could still be obtained by more natural and honest means. In particular by providing services still in great demand, whether babysitting or plumbing or house restoration. The corresponding jobs went out of fashion when the industrial myth proposed nut-fastening as a supreme accomplishment and social liberation. Realizing that the tunnel is very long may revamp such attitudes. Institutions and media could certainly help.

By changing emphasis I am also, perhaps incautiously, stating that Reaganomics, Thatcherism, Mitterandism, etc. are bound to break their promises, together with the monetarists, nervously turning disconnected knobs. My current problem, as a student of the system, is to determine how they could act otherwise, given better knowledge of the cyclical dynamics.

Dr. Marchetti's work on invention and innovation cycles is detailed further in RR-81-29, *Society as a Learning System: Discovery, Invention, and Innovation Cycles Revisited*, available from IIASA. A report under the same title as the present article is forthcoming. Dr. Marchetti came to IIASA in 1974 from EURATOM. He had previously worked in nuclear physics and engineering internationally and in his native Italy. He is a co-editor of the *International Journal of Hydrogen Energy* and of *Technological Forecasting and Social Change*, and holds an honorary degree in science from the University of Strathclyde, Glasgow, UK.

News from the Institute

Profile of New US NMO

The American Academy of Arts and Sciences, the new National Member Organization representing the scientific community of the United States in IIASA, is both a scholarly society honoring achievement in science, the arts, and public affairs, and a multidisciplinary study center involved in such contemporary issues as science policy, modern technology, ethnic and racial conflict, strategic arms limitation, and the environment and ecology.

Founded in 1780, the Academy has its national headquarters in Cambridge, Massachusetts, and regional centers in the midwest and on the Pacific coast. Its 2,300 fellows and 400 foreign honorary members represent distinction in the entire range of the intellectual disciplines and professions.

Its long-standing interest and involvement in international activities is reflected in the major role played by the Academy in the recent establishment of the International Foundation for Science, the Indo–US Cultural Commission, and the International Center of Insect Physiology and Ecology, as well as its participation in the Pugwash conferences on science and technology.

The American Academy's assumption of US membership in IIASA therefore "complements its existing program of international collaborative research," declares Academy President Herman Feshbach, who is also head of the Physics Department at the Massachusetts Institute of Technology. "The Academy has committed itself to strong, active participation in IIASA, and I look forward to becoming better acquainted with the Institute at first hand."

Meetings

Some 150 health officials and researchers discussed the modeling of health care systems in order to forecast all aspects of public health needs as demographic patterns shift in the industrialized countries. The Workshop met in Moscow, cosponsored by IIASA and the Ministry of Health of the USSR.

A task force meeting on multistate life history analysis held at IIASA was devoted to an interchange between practitioners of "macro" and "micro" demography: the multistate approach (described in this issue) developed at IIASA and the causal analysis evolving from sociological studies of individuals undergoing various transitions.

Providing policy makers and analysts with better operational perspectives was the purpose of a workshop at IIASA on information systems for integrated regional development. Analyses of existing systems in Czechoslovakia, France, the Netherlands, Sweden, and the USA, as well as the general class of regional information systems, received critical discussion.

There was an advisory meeting of economic experts in connection with the new IIASA project on Patterns of Economic Structural Change and Industrial Adjustment. They helped to set the research agenda for work in this field.

Preparations are under way for an International Energy Workshop, to be held at IIASA in June 1983, to develop a consistent perspective on global energy demand and supply.

Besides the seminars given by IIASA scholars on their research, visiting scientists often lecture on their work. Some recent speakers were: Dr. Ferenc Vissi, Head of the Department of Economic Mechanism of the Hungarian Planning Office, on recent changes in economic regulations and incentives; Ambassador Muchkund Dubey, Permanent Representative of India to the United Nations, Geneva, on negotiation processes involved in the North–South talks on international economic relations; Professor A.H.G. Rinnooy Kan of Erasmus University, Rotterdam and Drs. J.K. Lenstra and L. Stougie of the Amsterdam Mathematical Center, the Netherlands, on analysis of heuristics for hierarchical planning problems; Professors Kenneth Watt and Paul Craig, University of California at Davis, USA, on major driving forces in the world economy; Dr. Lars Ingelstam of Linköping University, Sweden, on the "informal" economy and changing use of time in post-industrial societies; and Dr. Martin Parry, University of Birmingham, UK, on identifying agricultural production areas that are especially vulnerable to climatic change.

Honors

Dr. Roger E. Levien, former Director of IIASA, and Professor Wolf Häfele, who headed the IIASA Energy Systems Program, each received the Award of Honor for Science and Art, First Class from the Republic of Austria on 31 January 1983.

Minister of Science and Research Dr. Hertha Firnberg presented the silver Ehrenzeichen Erster Klasse to them as individuals and as representatives of IIASA at ceremonies in the Ministry in Vienna. Dr. Levien was honored as "one who excels both in science and in science management," and the Award citation noted that "under his leadership, IIASA became a world-renowned institution of the highest scientific standing." Director of the Institute

from 1975 to 1981, Dr. Levien is now Director, Strategic Analysis, for the Xerox Corporation, USA. Professor Häfele, now Director General of the Nuclear Research Center, Jülich, Federal Republic of Germany, was rewarded for "his outstanding work in the field of energy and systems research." Professor Häfele was also a Deputy Director while at IIASA from 1973 to 1981.

Dr. Levien and Professor Häfele were also present at an Austria–IIASA Day held the same day at the Institute as part of the celebrations marking IIASA's tenth anniversary. Minister Firnberg, the Governor of the Province of Lower Austria in which IIASA is located, Siegfried Ludwig, and Mayor of Vienna Leopold Gratz made addresses, with IIASA scholars describing current Institute research to the assembly of diplomats and Austrian officials. Minister Firnberg's address is the basis of this issue's Guest's Corner.

New Titles

Regional Development Modeling: Theory and Practice. M. Albegov, A.E. Andersson, and F. Snickars, Editors. 423 pp.

Multiregional Economic Modeling: Practice and Prospect. B. Issaev, P. Nijkamp, P. Rietveld, and F. Snickars, Editors. 336 pp.

Available from North Holland Publishing Co., P.O. Box 211, NL1000, AE Amsterdam, the Netherlands, or Elsevier Science Publishing Co. Inc., 52 Vanderbilt Avenue, New York City, NY 10017, USA.

IIASA Collaborative Proceedings Series

CP-82-S7 Environmental Aspects in Global Modeling. Proceedings of the Seventh IIASA Symposium on Global Modeling. G. Bruckmann, Editor.

CP-82-S8 Progress in Nondifferentiable Optimization. E.A. Nurminski, Editor.

CP-82-S9 Innovation Policy and Company Strategy. H. Maier and J.M. Robinson, Editors.

CP-82-S10 The Kinki Integrated Regional Development Program. Y. Sawaragi and A. Straszak, Editors.

CP-82-S11 European and United States Case Studies in the Application of the CREAMS Model. V.A. Svetlosanov and W.G. Knisel

CP-82-S12 Multiobjective and Stochastic Optimization. M. Grauer, A. Lewandowski, and A. Wierzbicki.

IIASA Reports

Volume 6 Number 1 July–Sept. 1982.
Volume 6 Number 2 Oct.–Dec. 1982.

Research Reports

RR-82-34 Stochastic Water Requirements for Supplementary Irrigation in Water Resource Systems. Z. Kos.

RR-82-35 Multidimensional Mathematical Demography: An Overview. K.C. Land and A. Rogers. Reprinted from K.C. Land and A. Rogers, Editors, **Multidimensional Mathematical Demography**. New York: Academic Press. 1982.

RR-82-36 Siting Hazardous Facilities: Lessons from LNG. H.C. Kunreuther and J.W. Lathrop. Reprinted from *Risk Analysis*.

RR-82-37 Issues in Model Validation. A. Lewandowski. Reprinted from *Angewandte Systemanalyse*.

RR-82-38 On the Marginal Cost of Wastewater Services. S.H. Hanke and R. Wentworth. Reprinted from *Land Economics*.

RR-82-39 A Descriptive Model of Choice for Siting Facilities. H.C. Kunreuther, J.W. Lathrop, and J. Linnerooth. Reprinted from *Behavioral Science*.

RR-82-40 Reliability, Resilience, Robustness, and Vulnerability Criteria for Water Resource Systems. T. Hashimoto, D.P. Loucks, and J.R. Stedinger. Reprinted from *Water Resources Research*.

RR-82-41 Using Text Processing, Computer Networking and Satellite Telecommunication Technologies to Publish Primary Scientific and Technical Information. J. Page. Reprinted from Commission of the European Communities, **The Impact of New Technologies on Publishing**. Proceedings of the Symposium held in Luxembourg, November 1979. London: K.G. Saur. 1980.

RR-82-42 Structurally Stable Transport Flows and Patterns of Location. T. Puu.

RR-82-43 Recent Developments and Future Perspectives in Nonlinear System Theory. J.L. Casti. Reprinted from *SIAM Review*.

RR-82-44 An Approach to the Study of Transverse Mixing in Streams. L. Somlyody. Reprinted from *Journal of Hydraulic Research*.

RR-82-45 Management Control of Public and Not-for-Profit Activities. G. Hofstede. Reprinted from *Accounting, Organizations and Society*.

RR-82-46 Human Resources, Creativity and Innovation: The Conflict between Homo Faber and Homo Ludens. H.-D. Haustein. Reprinted from *Behavioral Science*.

RR-82-47 Equity, Efficiency, and Accessibility in Urban and Regional Health Care Systems. L.D. Mayhew and G. Leonardi. Reprinted from *Environment and Planning*.

RR-82-48 Urbanization and Development: Selected Essays. A. Rogers, Editor. Reprinted from *International Regional Science Review*.

Single copies of journal reprints are available free of charge. All other publications can be ordered from the Publications Department, IIASA.

Guest's Corner

Austria - IIASA's Home for a Decade

IIASA's tenth anniversary is again a welcome opportunity to affirm how well IIASA has become established in Austria and how widely the scientific achievements of the Institute have been recognized and appreciated, in Austria and around the world. Since 1969, when Austria first expressed its interest in becoming IIASA's host country, it has always been the declared goal of the Austrian government to make Austria an international meeting place for East and West, North and South. IIASA has been, and continues to be, one of the most important instruments in fulfilling this aim in the scientific sphere.

From the point of view of science policy, the continuous transfer of know-how, the fact that scientists are able to gain insights through cooperating with scientists from other countries in addressing international problems, is of particular importance. Since the founding of the Institute, more than fifty Austrian scientists have been able to participate in IIASA's various research programs. Austrian scientists acquire an understanding of international problems, not only theoretical but also practical, and this is one of the fundamental advantages for Austria in being IIASA's host country.

A further benefit of a permanent and strong link between Austrian scientists and the international scientific community is in countering the provincialism that often besets small countries.

The Austrian Academy of Sciences and the Austrian IIASA Commission under the chairmanship of Professor Leopold Schmetterer, Secretary General of the Academy, have contributed to the speedy dissemination of IIASA's research results in Austria. Austria certainly benefits from having easy access to these research results, as well as from other possibilities IIASA affords: the interrelations between research at the Institute and teaching and research at Austrian universities, the opportunity to have top international scientists as guest lecturers during their stay at IIASA, and the IIASA Summer Program for Young Scientists. Federal and regional authorities in Austria have followed the example of other countries in seeking IIASA's scientific advice and support in many areas and on many specific problems, and IIASA has always been willing to provide it. One of the first such collaborative projects was carried out under the leadership of Professor Holling, current Director of IIASA and former leader of the Ecology Project. The small resort of Obergurgl in the Tyrolean Alps was selected for a case study in a systematic analysis of the impact of the rapid growth of tourism on the local ecology.

In the field of energy research Austria has frequently made use of IIASA's expertise, for example in studying the possibilities of using solar power for Austria's energy supply, and in working out an energy plan for the City of Vienna in 1977. Also very important was the cooperation in making an inventory of national and international computer networks, and its consequences for Austrian universities and their electronic data processing. Without IIASA's assistance this would not have been possible. Last but not least, the embedding of the scientific activities of the Institute into a worldwide information and communication network represents an outstanding "systems" feature, which, together with its East–West cooperation, distinguishes IIASA from almost all other research establishments in the world. Efficient worldwide communication and scientific interaction has become an indispensable prerequisite for peace and understanding among peoples.

I would like to thank IIASA and all its staff for their work and for its enrichment of scientific life in Austria. The Austrian Chancellor, Dr. Bruno Kreisky, said at the IIASA Conference in May 1976 that "institutions such as IIASA and increasing cooperation will change the international situation. In your work you certainly serve science, the economy, and the striving for contacts at a very high level. But above all you serve peace." In this spirit I am happy to say that Austria will continue to do its best to support the Institute. I hope that the scientific relations between IIASA and its host country will continue to develop as positively as they have in the past. My best wishes are with IIASA for its next decade, and I hope that IIASA will continue its work in the service of science and in the cause of peace and understanding between peoples.

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