

TECHNICAL COOPERATION —

The Role of Science and Engineering in Promoting Economic Development

by Robert W. Oliver

Since the start of this academic year, the Institute has been investigating the problems of technical cooperation between the more and the less developed nations of the world. This is a continuation and an expansion of the more general study of Science and Public Affairs inaugurated in 1960-61 and made possible by a grant to Caltech from the Carnegie Corporation.

Guest lecturers, throughout the year, have included leading experts from various countries — engineers and scientists, economists, and administrators of various national and international agencies. Herewith, some lecture highlights.

The prescription for economic development, in a nutshell, is to increase the quantity and quality of capital. Development occurs (i.e. the average standard of living rises) because capital (man-made instruments of production) increases faster than the population. People can produce, and therefore consume, more when they have more and better tools and resources to work with.

Some economists spend a great deal of time belaboring this point. They may assume, for example, that, for every \$5 spent by a nation on new capital equipment, there is a corresponding increase of \$1 in the nation's annual output. Given a capital-output ratio of 5 to 1, one may compute the annual expenditure on capital needed to induce a desired increase in annual output. But calculations like these obscure the really interesting and significant problems of development: Which additions to the productive capacity of an economy ought to be undertaken first? To what extent can the output of a country be increased by applying modern technology and other-

wise stimulating scientific innovations?

Very early in any study of underdeveloped countries one becomes aware of vicious circles. The people of India are poor because they have so little capital relative to their labor force, but they cannot add a great deal to their stock of capital because too large a fraction of their output must be consumed.

The people of Egypt remain poor in part because the population expands so rapidly, but birth rates remain high because many individuals can see no relation between birth control and a higher standard of living. An improvement in techniques is subverted by tradition, but tradition is reinforced by the lack of knowledge of modern techniques. Any given project is unproductive because so many other projects need to be completed first, but this is true regardless of which project is considered first.

Paul Rosenstein-Rodan, professor of economics at MIT, illustrated this last dilemma in his description of the trials and tribulations of a button manufacturer who had been successful in northern Italy and had then attempted to establish a plant in southern Italy. In southern Italy there were no real estate brokers who could supply him with information about industrial sites. There were no established utilities which could provide him with inexpensive water and power. There were no industrial designers or building contractors familiar with the type of plant he wanted to construct. There were no financial institutions to provide the funds he needed to supplement his own resources. There was no pool of skilled labor upon which he could draw to staff his enterprise once it had begun operations. In short, there were none of the local resources which could provide him with the external economies any businessman would expect.

Professor Rosenstein-Rodan also pointed out that resources may be uneconomically allocated if development planners fail to consider the equilibrium prices, interest, and foreign exchange rates which would exist in a completely free market. A public power installation which appears desirable when capitalized at an interest rate of 3 percent (the artificial rate at which a government may be able to borrow money) might be undesirable when capitalized at 8 percent (the real cost of capital).

But while this consideration may be important in a complex, developing country like India, it may be unnecessarily academic in a country like Tunisia, where so much needs to be done that it does not really matter what is done first. As Albert Waterston of the World Bank indicated, investments in transportation, communication, and power are almost certain to be worthwhile. According to Andrew Kamarck, also of the World Bank, the problem may only be that the rate of return is too low to justify the investment of loanable funds in anything!

The Sociology of Development

It is all very well for economists to argue that development requires the accumulation of capital; such a generalization tells us nothing about the human processes involved. In the United States we are so accustomed to economic progress that we take for granted the culture patterns and the patterns of personal behavior that are the prerequisites of continuing, useful, capital accumulation.

How can people be induced to undertake business enterprise if the ownership of land is the highest evidence of social status? How can peasants be persuaded to improve the quality of their livestock if the quantity of cattle is a sign of wealth? How can people be induced to do anything in a new way if obedience to the traditions of the family and the tribe is regarded as the highest morality?

How can a modern, political, civil service be developed if nepotism is a time-honored practice? How can science flourish in a country where natural phenomena are explained by reference to astrology or witchcraft? How can farmers be persuaded to employ modern technology if they believe that any modification of traditional farming methods may reduce their already meager output?

How can the relatively few wealthy citizens of a country be induced to make their wealth available for productive enterprise if profits are regarded as unjust and interest immoral, and if the confiscation of property by newly successful political forces is likely? How can evolutionary political change and rule by law be obtained in a country having a long tradition of totalitarian government and of change by coup d'état or bloody revolution?

One of the most significant problems of underdeveloped areas — particularly the countries of Latin

America — is that of political instability and the absence of democratic traditions. Kal Silvert and Frank Bonilla of the American Universities Field Staff believe that modern political systems will not evolve in Latin America until such time as individuals develop a sense of loyalty to the nation or state. Of significance is their conclusion, based upon an extensive survey, that the highly educated, as well as the uneducated, in such countries as Argentina, Brazil, and Mexico regard loyalty to their class, whether economic or social, as more important than loyalty to the nation.

The Technical Cooperation lectures have been liberally sprinkled with illustrations of the problem of inducing change in underdeveloped countries. A technical assistance team in Burma was unable to persuade peasants to use rice seed which would increase output per acre by 25 percent. Finally they won over a local Buddhist priest who announced to the people that he wanted to bless the seed before it was planted. While behind a screen, the priest then substituted the new seed for the old.

Recently, in Nairobi, Kenya, the officials of a government agency complained that native businessmen were using funds provided by the government to buy wives rather than to improve their stores. The retort was that the wives could produce female children who could subsequently be sold — providing a fine financial return.

Among the more interesting discussions of the year were two dealing with entrepreneurs. In the widest sense, an entrepreneur is anyone who induces change; he is a creator. In the economic sense, an entrepreneur is one who induces change resulting in economic gain; he may develop a new product, a new production method, or a new form of economic organization. He may be, though he is distinct from, a manager. He can operate either in the private or the government sector of the economy. He is the motivating force behind development, and there is a sense in which it may be said that the problem of economic development is the problem of developing entrepreneurs.

Gus Papenek, professor of economics at Harvard University, recently completed an interesting study of entrepreneurs in Pakistan. He found that new entrepreneurs did emerge, after the flight from Pakistan of Hindu entrepreneurs, and in a situation where there was a domestic market protected by tariff and other trade barriers, an import-control system which enabled a few fortunate importers to obtain foreign technical help, and a rate of return on new investment which in general exceeded 50 percent.

The new entrepreneurs behaved very much like those of the early industrial revolution in England. They seemed not to be hampered by religious or cultural traditions and were perfectly willing to reinvest their earnings in their expanding enterprises. Their investments have resulted in a substantial increase in the total production of Pakistan. The stan-

dard of living of the entire population is increasing, and the rate of new investment continues high, even though the rate of return is no longer as high as it was immediately following the birth of Pakistan as an independent nation.

But the pattern in Pakistan is not being repeated in other underdeveloped countries.

Everett Hagen, professor of economics at MIT, discussed his theory—based on research into the relevant histories of such diverse countries as Japan, Colombia, Burma, pre-revolutionary Russia, and England—that entrepreneurs are most likely to come from a certain class of people. This class, Hagen feels, must evolve over several generations from an initially aristocratic group which, for one reason or another, has become disenchanted with the established, majority, ruling group. Eventually, finding it necessary to demonstrate to themselves that they are really as good as everybody else, they become deviants who seek in some new way to reestablish their social positions. They break with tradition, though not in a revolutionary way. They induce social and cultural change. When they devote their attention to economic matters, they become entrepreneurs.

While this summary cannot do justice to Hagen's work, it can, perhaps, illustrate the importance of sociological research if we are to understand the processes by which individuals and institutions can be modified so that economic development may

occur. It may also help us to understand a point emphasized by Albert Waterston: Economic development will not occur unless a society really wants it to occur—unless a society is willing to break with its own traditions in the interests of modernization.

The Technology of Development

Gladwin Young, deputy director of the Soil Conservation Service of the U.S. Department of Agriculture, estimated that the agricultural output of underdeveloped countries could be increased as much as tenfold through the application of modern agricultural techniques.

At the same time, many visitors warned against the too-easy assumption that production techniques can be transferred intact from the United States to underdeveloped countries. Some modification of technology is almost always required; in some cases the modifications are so great that they may almost be classed as new discoveries. Certainly scientific research of an applied, if not a fundamental, nature is a requirement of economic development.

Montague Yudelman, professor of economics at Harvard, made this point particularly well when he compared the agricultural improvement program successfully carried out by the Rockefeller Foundation in Mexico and the infamous ground-nuts scheme in Tanganyika, Africa.

CARNEGIE PROGRAM: Technical Cooperation

Lecturers, 1961-1962

Benjamin Spiro, Inter-American Bank
— *The Alliance for Progress*

Paul Rosenstein-Rodan, Center for International Studies, MIT —

Shadow Prices and Economic Planning

J. Burke Knapp, International Bank for Reconstruction and Development
— *The World Bank and Project Lending*

Montague Yudelman, Harvard University —

Agricultural Experiments in Tanganyika and Mexico

Djanaghir Boushehri, International Monetary Fund —

Price Stability and Economic Development

Lyman Wilbur, Morrison-Knudson, Inc. —

Practical Engineering Overseas

Max Millikan, Center for International Studies, MIT —

Foreign Aid: Lessons and Prospects

Gustav Papanek, Harvard University
— *Private Domestic Investment in Pakistan*

Albert Waterston, International Bank for Reconstruction and Development
— *The Need for Micro-economic Planning*

Laurence Taylor, University of California —

The Significance of Agriculture

Everett Hagen, Center for International Studies, MIT —

The Non-Economic Origins of Economic Development

Julius Kiano, former Minister of Finance, Kenya —

The Future of Kenya

Walsh McDermott, Cornell University Medical College —

The Role of Science in Development Assistance

Maurice Albertson, Colorado State University Research Foundation —

American Universities and Education in the Underdeveloped Countries

Egon T. Degens, Caltech —

Water Problems in the Western Egyptian Desert

Gen. Sir Geoffrey Bourne, Aluminium Development Association —

Combating Communist Subversion in Underdeveloped Countries

Gladwin Young, U.S. Dept. of Agriculture —

Water Resource Development in Underdeveloped Countries

Andrew Kamarck, International Bank for Reconstruction and Development
— *Development Projects in Africa*

Frank van Hoek, The Organization for Economic Cooperation and Development —

The Technical Assistance Program of the Organization for Economic Cooperation and Development

C. R. DeKiewiet —

American Policy in Sub-Saharan Africa

Gilbert White, University of Chicago
— *The Mekong Valley*

Hon. Loyd V. Steere, former U.S. Minister to Rhodesia and Nyasaland
— *Rhodesian Political Leaders*

Charles Nixon, UCLA —

Political Process and Parties in Rhodesia

Taylor Ostrander, American Metals Climax —

American Metals Climax in Rhodesia

Richard Logan, UCLA —

Natural Resources and their Uses in S.W. Africa

R. J. Hammond, Stanford Food Research Institute —

Economic History of Angola and Mozambique

Hilda Kuper, University of Natal —

Economic Attitudes of the Swazis

In the first case, operating on a small, pilot project, an outstanding American biochemist discovered a seed which, together with the complementary fertilizer, irrigation, and treatment for pests and insects, could substantially increase the output of corn in Mexico.

In Africa, following an inadequate survey, the British Government undertook a large-scale agricultural project. Three years and 70 million dollars later, it was abandoned as a total failure. The farm machinery was ill-suited to African soils, as were the plowing and irrigation techniques. The difficulties of dealing with tropical vegetation were grossly underestimated. The project demonstrated that money is an inadequate substitute for time, knowledge, and research.

The extent to which modern technology may contribute to an evaluation of a development plan was beautifully illustrated by two lecturers who discussed "Project New Valley," (*ES* - November 1961), a scheme for irrigating the Western Egyptian Desert. Egon Degens, assistant professor of geology at Caltech, presented geologic evidence that the underground water in this desert is fossil water; it is not being replenished. Thus, it would be folly to carry out the Egyptian Government's plan for resettling 10 to 15 million people in this arid area.

Paul Keim, professor of civil engineering at the University of California, suggested that, by using modern reclamation techniques, the land area of Egypt which could be irrigated by the Nile even without the high Aswan dam might be increased by as much as 30 percent.

The need for high-level scientific and technical assistance to underdeveloped countries is great. This is true, for example, in the fields of nutrition and public health. Henry Borsook, Caltech professor of biochemistry, believes that the present output of potential food is adequate even in the most poverty-stricken areas of the world; the problem is that available plants and grasses are not being wisely used.

Harrison Brown, Caltech professor of geochemistry, suggested that the development of a primitive pump for rural areas in India, even if it were only 5 percent efficient, might obviate the need to use cattle to produce energy. Small devices to produce energy at the village level might be enormously useful.

Research into the problems of technical education is also necessary. As recently as 10 years ago, the Belgian government thought in terms of independence for the Belgian Congo by the year 2000. When independence was suddenly granted, the native Africans were sadly lacking in secondary and higher education. The Congo tragedy could be repeated in such other countries as Angola, Mozambique, Nyasaland, and Northern Rhodesia. C. R. DeKiewiet, formerly president of the University of Rochester, and Maurice Albertson, director of the Colorado State University Research Foundation, raised some interesting questions concerning education. Are the techniques of

London University or Oxford or Harvard suited to the requirements of Nigeria or Kenya or Tanganyika? Is it more efficient to bring students from Africa or Asia to study in Europe or the United States, or to send European and American professors to teach and conduct research on the spot in underdeveloped countries? In the case of foreign students who are trained in the United States, are present educational techniques appropriate? Why is it that so many foreign students who study in the United States prefer not to return to their native countries? Why is it that the students who do return find it difficult to obtain positions commensurate with their training? It has been observed by many visitors to Caltech that well-educated people in underdeveloped countries regard it as beneath their dignity to work with their hands. Can such attitudes be overcome through education?

Foreign Aid

As the British forces under Gen. Sir Geoffrey Bourne discovered in Malaya, Western nations cannot expect to win the battle for men's minds until native peoples become convinced that the Western nations share their aspirations for a better life, both politically and economically. But Americans are learning that economic development requires more than money and that a nation cannot be made to develop solely as a consequence of external, foreign assistance.

Max Millikan, director of the Center for International Studies at MIT, analyzed the weaknesses of the American foreign aid program and presented suggestions for improvement. Until recently, the aid program paid too little attention to long-range planning and to the development of human resources. Countries receiving American economic assistance must be induced to prepare long-term development programs. We must insist upon honesty in government, tax and land reform, political and fiscal stability, and, above all, a demonstrated willingness on the part of recipient nations to help themselves. While it may be necessary to give some assistance for purely political reasons, a part of our foreign-aid budget should be allocated for strictly economic development, and economic development should be financed once the criteria have been met, regardless of international political considerations.

Edward Fei, director of the Research and Evaluation Staff of the Agency for International Development, pointed out that there is a pressing need for qualified advisers to the governments of underdeveloped countries. He also discussed a new facet of the AID program: the sponsorship of research. AID is prepared to finance studies of such matters as the role of technical education in promoting development, the impact of urbanization on local customs, and the importance of wage incentives in fostering labor mobility. AID is anxious to receive research proposals concerning specific, substantive questions. It is

also anxious to learn which institutions in the United States are capable of supplying teams of high-level advisers to underdeveloped countries.

Technical Cooperation in Southern Africa

The Technical Cooperation Seminar was inaugurated at Caltech in September 1961. Following weekly public lectures, members of both scientific and humanities faculties met with the guest speakers in seminars. An innovation of the Technical Cooperation Seminar has been the preparation of research papers by a select group of graduate students who have studied the relation between their particular scientific disciplines and the problems of underdeveloped countries.

By the end of 1961 it was apparent that the Seminar was a useful addition to the educational curriculum and was compatible with the philosophy of the Carnegie program: scientists, engineers and social scientists could explore together the relations between science and some aspects of public affairs.

But the Seminar was primarily educational, and some members of the faculty began to wonder if the program could not be expanded to encompass research as well. Within the Humanities Division a proposal was prepared that research be undertaken concerning the problems of economic development in southern Africa. This request was granted by the Division chairmen and the Board of Trustees in January 1962, and preparations for launching the project are now well underway.

A long-range social science objective will be to analyze (perhaps even to prepare) projections of the future economic development of the nations of southern Africa. Included in such an analysis will be research into the history and contemporary politics of the area, its international relations, its present and projected resources, its patterns of foreign trade, its technological and educational facilities, and the culture patterns of the people. This research will be useful in itself; it will also be useful for coordinating investigations in such specific scientific areas as food (including agriculture and nutrition), water, energy, housing, public health, and technical education.

The problems of economic development and of technical cooperation between the more and the less developed countries of the world are not confined to any particular area of the world. The broad problems of development are the same in Brazil, Nigeria, India, and Indonesia. Thus, since the Technical Cooperation research group is interested in general principles, it does not intend to confine its attention wholly to any single part of the world. Nevertheless, research of this type can be conducted more systematically if it is focused, at least initially, upon a particular area.

During the summer of 1962 a field team will visit southern Africa to obtain an overall impression of the area. In addition, Harold Wayland, professor of ap-

plied mechanics, and Alan Sweezy, professor of economics, will be attending economic development conferences in France and Austria, and James Davies, professor of political science, will be analyzing political conditions in Portugal.

Robert Huttenback will combine his visit to Africa with an expedition to India where, among other things, he will be the first member of the Caltech faculty to participate on the spot in organizing the new technical institute at Kanpur. From Caltech's side, this important project is under the general direction of Professors Donald Hudson, George Houser, and Norman Brooks.

Caltech is, and intends to remain, devoted to high-level research and education in engineering and basic science. Nevertheless, the program of the Institute may be strengthened by this expansion of the work of the Humanities Division. As scientists are drawn increasingly into public affairs, they find it useful to collaborate with social scientists in systematic studies of the problems which confront mankind. Under the Carnegie program, such collaboration has been possible in the areas of Arms Control and Technical Cooperation. It is hoped that this work will continue, for it is clear that modern engineering and science, when harnessed for peaceful purposes, can do much to increase the material well being of people everywhere.

Graduate Student Papers *Technical Cooperation Seminar*

- C. R. Haden —
Technical Assistance on a Smaller Scale
- G. Gutner —
Aspects of Water Resources Development in Mexico.
- S. F. Masri —
Education and the Economic Development of the United Arab Republic
- A. Abu-Shumays —
Economical and Technical Aspects of Egypt's Aswan High Dam Project
- H. A. Thiessen —
The Rehabilitation of the Pacific Railway and the Development of Northwestern Mexico
- P. W. Purdom —
The Program of the Institute of Public Administration of the University of the Philippines
- R. F. Gebhardt —
Mineral Development
- S. R. Harrison —
The Importance of Agricultural Exports to the Mexican Economy
- R. A. Svenson —
Use of Microwave Systems in Communications Networks of Underdeveloped Countries
- J. J. Kennedy —
Protein Malnutrition in Sub-Saharan Africa
- D. B. Forrest —
The Entrepreneurial Function in the Context of the Developmental Process
- O. C. Meirelles —
Electric Power in the Centro-Southern Region of Brazil
- S. C. Choy —
The Education of Foreign Students in the United States