

Technology as a Major Limiting Factor in Economic Development

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I. Introduction

Since WWII we have witnessed three major revolutions. First, the political revolution has given self-government to nearly a third of the world's population and has brought with it a "revolution of rising expectations." Second, the revolution in communication and transportation has broken down the barrier of language and distance, and the dynamism of ideas can no longer be contained within the limits dictated by social privilege or political considerations. Third, the technological revolution has left men's footprints on the moon for the first time in the entire history of mankind and has opened a new era where everything seems possible.

People of the developing countries (DCs) are becoming aware of the existence of the affluent world and are no longer satisfied with a life of mere survival. They want a higher standard of living and opportunity to develop their full potential. The demands of the people of the DCs are legitimate and cannot be overlooked. In this age of instant happenings, people are becoming increasingly impatient. They are no longer content with the gradual process of industrial development achieved by advanced countries (ACs) since the Industrial Revolution.

In spite of great anxiety on the part of the DCs to achieve rapid economic development the results so far have been disappointing for many DCs. No contemporary problem of our time is more urgent and important than the misery and poverty of two-thirds of the world population. The polarization of rich and poor is politically dangerous for world peace, socially undesirable, and morally intolerable.

The purpose of this article is, then, to emphasize the crucial role

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played by technology in economic development by reviewing empirical studies and to suggest means by which technology can be effectively transmitted to DCs in order to close the gap between ACs and DCs.

II. Technology Defined

"Technology" is a generic term that tends to invite misunderstanding. It is misleading, therefore, to assume that everyone uses the term in the same context. A working definition of technology is clearly needed.

In its broadest meaning, technology connotes a wide range of the practical knowledge and skills evolving from hunting, fishing, agriculture, mining through manufacturing to means of communication, medicine, military; and space. In this sense, technology can be conceived of as the body of "skills, knowledge, and procedures for making, using and doing useful things."¹ In a narrow sense, technology has been defined as "the body of knowledge that is applicable to the production of goods and the creation of new goods."²

We are concerned here primarily with modern industrial technology in the context of its role in economic development. Technology stresses practical purpose. It refers not only to the state of technical knowledge, but also to its application to practical purpose in a particular field. For our purpose, therefore, technology is defined as to encompass not only technical knowledge and skills concerning the production of goods and the creation of new goods, but also managerial knowledge and skills involved in planning, organizing, staffing, controlling, and carrying out production and marketing of the goods produced. The inclusion of managerial knowledge and skills in our definition of technology is somewhat broader than the general usage of the term. It is important to understand at the outset, therefore, what is meant by technology in our discussion to avoid any confusion and misunderstanding.

Technology does not grow in an autonomous fashion, unaffected by external forces. Technology is the result of conscious effort devoted to technological change, strongly influenced by economic demand and profitability. The process of technological change consists of three distinct phases: invention, innovation, and diffusion. The first step in the process of technological change is invention. Invention is the creation of new products which have never been made before or new methods which have never been used before. At this stage only the technical feasibility of such products or methods has been demonstrated through small-scale testing which may become workable full-scale

1 Merrill (1968, p. 576).

2 Root (1968, p. 17).

plans through further development.

Innovation is the next step, which is the actual implementation of the new process and the production of the new products. Invention per se, important as it is, does not play a significant role in the process of technological change unless it is followed by innovation which transforms the possibility into reality. After invention has been put into full-scale practical use, diffusion of innovations will further spread technological change.

Diffusion is thus basically imitative and involves the gradual replacement of old methods by the new. One example will suffice to illustrate the three phases of technological change. The most frequently used oxygen steel process is the L-D (Linz-Donawitz) process. Its first successful test took place at Linz, Austria in June, 1949 (invention phase) followed by pilot-plan development at Linz and Donawitz. The Linz plant went into production in November, 1952 and the Donawitz plant in May, 1953 (innovation phase). The L-D process was adopted in Canada and the United States in 1954 (diffusion phase).³

The distinction between innovation and diffusion is not always clear. For example, should we consider an entrepreneur who borrows a new method from foreign countries and first introduces it in the domestic economy an innovator or a special kind of imitator? Rarely is an innovation diffused in unmodified form between countries that differ in productive resources, demand, levels of technical know-how, and institutional patterns. According to Scoville, the process of transplanting new methods from one country to another without drastic modification of the principles involved or their application should be regarded as diffusion if both economies have the same culture, otherwise the initial borrowing should be viewed as an innovation and only subsequent imitations considered as instances of diffusion.⁴ Thus, the adoption of the oxygen steel process by Indian steel producers would be innovation rather than diffusion.

III. Technology and the Rate of Economic Growth

The rate of economic growth is determined by many complementary factors such as capital, labor, natural resources, and technology. Deficiencies in one or several factors might cause the rate of economic growth to slow down unless the limitation is overcome.

3 See Malada and Knight (1967, pp. 531-558). Despite the economic advantages of the oxygen steel process, its adoption by major steel producers of the world made a very slow start. See Ray (1969, Table 47, p. 81).

4 Scoville (1951, pp. 347-348).

The relationship between the various inputs of productive resources and output is expressed in the classic concept of a production function. In its most general form, the production function can be written using Meade's notation⁵ as:

$$Y = F(K, L, N, t)$$

where Y = net output,

K = the existing stock of capital goods,

L = the amount of labor,

N = the amount of natural resources, and

t = time whose passage reflects technological progress.

If we consider machines, plant, and other capital goods together with natural resources as the result of investment, and labor as the result of investment in "human capital," the production function can be written simply as $Y = F(K, t)$ where changes in K represent capital formation and changes in t , technological change. Thus, we have only two important determinants of economic growth, namely, capital formation and technological change. To what extent, does each factor contribute to the rate of economic growth?

Until the middle 1950's, capital formation was considered as the major factor responsible for the rate of economic growth by almost all economists. Other unquantifiable inputs — education, training, managerial and technical know-how, etc. — were either ignored or they were conveniently taken into the familiar assumption of "ceteris paribus" or "other things being equal." Thus, changes in "other things" were regarded as "exogenous," and their influence was eliminated from the theoretical growth models.

The omission of discussion of technological change, however, should not be taken as implying a subsidiary role for such changes. The omission is to some extent, "a reflection of the paucity of our understanding and practical knowledge"⁶ concerning technological change. Schumpeter was one of the first economists who emphasized factors other than capital as being more important. He wrote:

The slow and continuous increase in time of the national supply of productive means and savings is obviously an important factor in explaining the course of economic history through the centuries, but it is completely overshadowed by the fact that development consists primarily in employing existing resources in a different way, in doing new things with them, irrespective of whether those resources increase or not.⁷

5 For a detailed treatment of the production function, see Meade (1962, pp. 8-29).

6 Eckaus (1966, p. 101).

7 Schumpeter (1934, p. 68).

Only recently has attention turned to the decisive role that technology plays not as an incident to capital but as an independent factor in economic development. Several empirical studies have been made to attribute quantitatively the increase in productivity, i.e., output per man-hour, in the United States of capital formation and technological change.

Based on data during the eighty-year period from 1869-73 to 1949-53 in the United States, Fabricant observes: "If national income per capita has been multiplied over fourfold during the past eight decades and total input per capita has risen by less than a fifth, it follows that the major source of our economic advance has been a vastly improved efficiency."⁸

Abramovitz came to a similar conclusion in a statistical analysis of the same period. Net national product in the decade 1944-53 stood about thirteen times as high as it was in 1869-78. This increase implies an average rate of growth of 3.5 percent per annum. Population, however, more than tripled in the same period. Net product per capita, therefore, approximately quadrupled, implying an average rate of growth of 1.9 percent per annum. The quadrupling of net national product per capita resulted in part from an increase in capital formation and in part from a rise in the productivity. However, the relative contributions of these two factors were very different. Abramovitz concludes:

The source of the great increase in net product per head was not mainly an increase in labor input per head, not even an increase in capital per head as these elements are conventionally conceived and measured. Its source must be sought principally in the complex of little understood forces which caused productivity, that is, output per unit of utilized resources, to rise.⁹

What cause the productivity to rise? Over the forty-year period between 1909 and 1949, productivity in the United States doubled. Solow's study attributed 87½ percent of the increase to technological change and the remaining 12½ percent to increased use of capital.¹⁰ In a later article Solow maintains that "capital formation is not the only source of growth in productivity. Investment is at best a necessary condition for growth, surely not a sufficient condition."¹¹

Massell examined the annual increases in output per man-hour of labor in the manufacturing sector of the United States economy between 1919 and 1955. His calculation indicates that up to 90 per-

8 Fabricant (1954, p. 8).

9 Abramovitz (1956, p. 6).

10 Solow (1957, p. 320).

11 Solow (1962, p. 86).

cent of the increase in productivity during this period was due to technological change. Massell concludes by observing:

The present paper offers evidence to support the view that technological change is of overriding importance in bringing about increased labor productivity over time and that there is a need for economists to shift emphasis from the theory of capital to the theory of technical progress, as an explanation of the growth in aggregate output.¹²

The relative contribution of technological change can be summarized by the table below.

Table 1

Attribution of Productivity Increase, United States

Author and Scope of Study	(percent)
	Share Attributed to Technical Change
Abramovitz: NNP per capita, 1869-78 to 1944-53	80-95
Solow, with correction by Hogan of an arithmetic error, and definition of lower limit by Levine: Private nonagricultural output man-hour, 1909-49	81-90
Massell: Manufacturing output per man-hour, apparently 1919-55	67-90
Massell: Same, by different method	87

Source: Hagen (1968, Table 8-2, p. 182).

Estimates of national products over long period are inevitably biased by statistical errors and uncertainties of conception. Different methods produce different estimates. Thus, they must be treated with a great deal of reserve. Even when all due allowance for possible errors in arriving at specific figures has been made, however, it is clear that the relative contribution of capital formation to the rate of economic growth is completely overpowered by that of technological

12 Massell (1960, p. 188). Massell produced later, based on the same data but by different method, 87 percent as the relative contribution of technological change to the increase in productivity. See Massell (1962, pp. 336-332).

change. In a recent and more exhaustive study on determinants of economic growth based on national income data for the period 1950-1962 in nine Western countries, Denison has presented somewhat different estimates summarized in Table 2.

Table 2

Percentage Distributions of Growth Rates of Adjusted National Income and National Income Per Person Employed among the Sources of Growth, 1950-62

(percent)

Sources of Growth Country	Total National Income			National Income per Person Employed		
	Total Factor Input	Output/ Unit of Input	Adjusted National Income	Total Factor Input	Output/ Unit of Input	Adjusted National Income
U.S.	58	42	100	36	62	100
N.W. ^a						
Europe	36	64	100	20	80	100
Italy	28	72	100	20	80	100

Sources: Compiled from Denison (1967, Tables 21-2, 21-4, and 21-20, p. 299, p. 301, p. 317).

^aBelgium, Denmark, France, Germany, Netherlands, Norway, and United Kingdom.

As indicated in Table 2, sources of growth consist of total factor input and output per unit of input. In Denison's original tables, total factor input includes capital, labor, and land. Capital is divided into dwellings, international assets, inventories, nonresidential structures and equipment. Labor is subclassified into employment, hours of work, age-sex composition, and education. Output per unit of input includes advances of knowledge, changes in the lag in the application of knowledge, general efficiency, errors and omissions, improved allocation of resources, economies of scale, etc.

The percentage distributions indicate that over the 1950-62 period in the United States, the increase in total factor input contributed 58 percent of the 3.36 percent (not shown in the table) adjusted growth

rate of total national income with the remaining contributed by the increase in output per unit of input. Contributions to the 2.19 per cent (not shown in the table) adjusted growth rate of national income per person employed in 1950-62 show different results, since employment disappears from the accounting and the contributions of other inputs depend upon changes in their quantities relative to the change in employment. The increase in total factor input per person employed contributed 36 percent, and the increase in output per unit of input, 62 percent.

In case of European countries, the increase in output per unit of input contributed more than the increase in total factor input, 64 percent in Northwest Europe and 72 percent in Italy of the adjusted growth rate of total national income. The increase in total factor input contributed only 20 percent to the adjusted growth rate of national income per person employed in 1950-62 in Europe with 80 percent contributed by the increase in productivity.

It is difficult to single out any one factor as the most important cause of the rate of economic growth. It is hardly surprising to find, however, that in Denison's exhaustive study with 23 different sources of economic growth, advances of knowledge, one of the major contributing factors to the increase in productivity, stood always top in the number of appearances of the five largest sources of economic growth in nine countries he studied.¹³ The National Commission on Technology, Automation, and Economic Progress presents in its report an overwhelming evidence that "technology stimulates the rate and volume of economic growth, and that the infusion of new technology can speed the rate of economic growth."¹⁴

IV. Technology and the Developing Countries

The conclusion that technology is a major limiting factor in economic development is hardly challengeable in ACs for which there is ample empirical evidence. But does this conclusion hold for DCs as well? One cannot automatically assume that what is true in ACs whose conditions are quite different from those of DCs is necessarily true of technologically unsophisticated DCs.

In the past couple of decades, a large part of the economic literatures on economic development has focused on difficulties in capital formation as the major factor responsible for underdevelopment in the low-income countries. The difficulties are assumed to be associated

13 The other four largest sources were nonresidential structures and equipment, economies of scale, employment, and contraction of agricultural inputs. See Denison (1967, Tables 21-21, 21-22, p. 318).

14 National Commission (1966, p. 103).

with the traditional doctrine of "the vicious circle of poverty," i.e., a chain of low income — inability to save — low investment — low output.¹⁵

The basic reasons behind this approach are enumerated: first, there is a direct relationship between net capital investment and growth, and that what is required to increase the rate of growth is to increase the rate of capital formation. Thus, the central problem in growth is capital formation. Second, it is assumed that sufficient technological creativity to carry forward economic growth is present in all societies.¹⁶

This neat but oversimplified approach is in fact misleading in that it neglects factors other than capital that are of considerable importance. Economic development is a complex process and is much more difficult to achieve than is often realized. Injection of one or more factors will not automatically bring about desired economic development. Capital is at best a necessary condition but not a sufficient condition of growth.

An empirical study on Nigerian manufacturing industries concludes:

The magnitude of labor productivity depends on the effective utilization of the capital formation, and a major determinant of this effectiveness is the base of science and technology. The narrowness of this base and the rudimentary nature of technological development in Nigeria has greatly mitigated the effectiveness of capital utilization in spite of the significant capital formation that took place during the 1950s and 1960s. This leads us to explain the gap in productivity gains between the ACs and the DCs by the disproportionate technological investment for effective use of capital formation rather than the process of capital formation itself.¹⁷

Virtually all DCs suffer from extreme shortages of managerial and technical capabilities. The scarcity of these elements is often a greater handicap to economic development than the shortage of capital.¹⁸ The Advisory Committee on Private Enterprise in Foreign Aid reports:

15 See Nurkse (1960, pp. 4-5).

16 Hagen (1962, p. 49).

17 Thomas (1975, p. 109).

18 See Baranson (1966, p. 259). Baranson points out that contrary to what is commonly believed, shortages of capital and machine skills are not the main source of difficulty in developing countries. The major problems are associated with among others the lack of managerial capabilities. *Ibid.*

While capital is scarce in the less developed countries, the more subtle and difficult shortcoming is human and institutional. The most basic problem in the whole development effort is that of transferring skills and technology, and to some degree attitudes, to individuals and institutions in the less developed countries.¹⁹

In terms of production, one can argue that the difference between ACs and DCs is primarily a difference of technological capability.²⁰ Yet, in spite of its importance, the vast technological needs of the DCs have not been adequately assessed or taken into consideration by economists or government officials in both ACs and DCs. Technological deficiency cuts across the entire range of required skills and constitutes a major limiting factor to a higher rate of economic growth.

This being so, why is technological capability taken for granted in the economic theories? According to Hagen, there are two reasons. "One reason no doubt," he writes, "is ethnocentricity." In Western society technological creativity is assumed as a fact of human nature rather than a culturally acquired trait. Another perhaps more important reason is the "economic thought since the second quarter of the nineteenth century, in which present-day economists are steeped, has ignored not only creativity but also the process of technological change itself."²¹

The extraordinary success of the Marshall Plan in rehabilitating the postwar European economy whose success was largely due to massive inflow of external capital led many economists and public officials to believe that similarly oriented programs would bring about rapid economic growth in DCs as well. Thus, it became fashionable for DCs to draw up a five-year plan exclusively in money terms. One thing development planners overlooked was the fact that while the shortage of capital was common in both the war-devasted postwar Europe and the DCs, the former had technological capability required for rapid economic growth, whereas the latter lacked both. Results have been predictably disappointing. Even with adequate financial backing, the five-year plans failed to meet their targets. Economists were driven into taking a hard look at factors other than capital. From the late 1950's onward, central emphasis began to shift from conventional inputs to "nonconventional inputs" including investment in "human capital" and "human determination", as well as managerial and technical know-how as the major causes of economic

19 Foreign Aid (1965, pp. 6-7).

20 Bachman (1968, p. 13)

21 Hagen (1962, p. 50).

development.²²

If technology is a major limiting factor to a higher rate of economic growth in DCs as well, questions arise: Can modern industrial technology which has been developed in and for the requirements of the ACs be effectively used in accelerating the rate of economic growth in DCs? Do DCs need a new type of technology which is especially suited to the existing conditions of DCs?

There is an argument for an "intermediate level of technology" or a "third technology" as a means for massive industrialization in DCs. According to this argument, advanced Western technology is by no means ideally suited to the conditions of DCs characterized by abundant labor, shortage of capital, lack of properly trained managerial and technical personnel, since such technology has evolved along lines appropriate to the conditions of the countries which created it, meaning that it uses little labor and a great deal of capital, and depends in its operations on the existence of a reservoir of skilled labor and technically trained personnel. Thus, there is a need for technology which is neither Western technology of the past nor the latest technology, but an "intermediate technology" or a "third technology" which is specially designed to suit the unique conditions of the DCs.²³

On the other hand, there is another view whose proponents argue for the use of the latest Western technology as a shortcut to rapid development in DCs. For example, Leontief writes:

The new technology will probably have a much more revolutionary effect on the so-called underdeveloped countries than on the U.S. or other old industrial nations. Shortages of capital and lack of a properly conditioned and educated labor force have been the two major obstacles to rapid industrialization of such backward areas. Now automatic production, with its relatively low capital and labor requirements per unit of output, radically changes their prospects. Instead of trying to lift the whole economy by the slow, painful methods of the past, an industrially backward country may take the dramatic shortcut, building a few large, up-to-date automatic plants.²⁴

²² Examples of investment in human capital are direct expenditures on education, health, and internal migration to take advantage of better job opportunities. See Schultz (1961, pp. 1-17). Schultz asserts that many paradoxes and puzzles about our dynamic, growing economy can be resolved once human investment is taken into account. *Ibid.*, p. 3. Professor Malenbaum also points out that the nonhuman inputs into the expansion process are much less important than the human determination. See Malenbaum (1958, p. 20).

²³ See Gill (1967, p. 86), and also see Alexander (1964, p. 115).

²⁴ Leontief (1955, p. 79).

Leontief's concepts are widely shared with those who believe, that in modern technology, there is the means by which DCs can avoid or reduce the sacrifices and the time span required to achieve a higher rate of economic development.

Not all the latest Western technology can be applied to DCs with the same effectiveness in light of the unique conditions existing in these countries. It would be impossible to use electrical tools and equipment where there is no electricity. Certain prerequisites have to be met for the effective use of modern technology. It is, however, largely a matter of adaptation to the particular circumstances. There may be certain short-run disadvantages resulting from the use of advanced technology in DCs. Capital-intensive and labor-saving methods may lead these countries in wasteful directions. It seems, however, that the long-run advantage of having advanced technology available to be adapted would far outweigh the contrary considerations. It is the basic assumption of the writer that there is body of technology defined in its broad term which can be effectively transferred across national boundaries, to the benefit of the receiving countries, developed or developing.

V. The Technological Gap

Vast amount of technology are concentrated in a few ACs. More than three quarters of the scientific and technical information originates in the OECD countries — Western Europe, North America, and Japan.²⁵ These countries add new technology at an increasing rate to their already existing stock of technology. The result, worldwide, is so called the technological gap.

To determine the extent and the nature of the technological gap, it is helpful to distinguish between (1) differences in the development of technological capability, (2) differences in the performance of technological innovation, and (3) differences in the performance of diffusing technological innovation.

The factors influencing the technological capability are the extent of R&D activities and educational efforts of a country. The R & D gap between ACs and DCs is wide both in absolute and relative terms. In 1973, for example, the United States and West Germany devoted 3.1 percent of their GNP to R & D, and Japan 2.2 percent, while Korea spent 0.4 percent.²⁶ No comparable figures are available for all DCs, but we can safely assume that at present time R & D efforts of DCs must be very small compared with those of ACs both in absolute and relative terms.

25 OECD Observer (1968, p. 36).

26 MOST (1974, p. 5), AST (1975, p. 246).

There is a significant gap between the level of technological education in DCs and that of ACs. The educational gap between DCs and ACs seems much greater in the availability of scientists and engineers. On the average, only about 1 percent of the labor force of DCs are people with high level skills as compared with 4 or 5 percent in ACs.²⁷

A significant gap exists between ACs and DCs in the area of technological innovation which is the actual implementation of new products or new processes. For example, of the recent 140 innovations examined by OECD, U.S.-based firms have originated approximately 60 percent. They also have the largest share (approximately 30 percent) of world exports in research-intensive product groups.²⁸ It is safe to assume that the majority of technological innovation are done by the U.S. and other ACs.

Technological innovation may spread from one country to another by way of imitation. There are very few countries, if any, which have achieved economic development exclusively on the basis of their own resources without drawing on the technology developed in other countries. However, countries differ considerably in their willingness and ability to utilize imported technology. DCs have shown very poor performance in the diffusion of innovation through imitation. A kind of vicious circle is operative here. Because DCs lack industrial skills and innovative ability they are unable to imitate imported technology through local innovation that would help move them out of economic stagnation.²⁹ The technological gap among ACs is largely a consequence of differences in technological innovation whereas the gap between ACs and DCs is due to the combined shortages of technological capability, innovation, and diffusion in DCs.

The stock of technology in any country can be increased mainly in two ways, i.e., by importing already existing technology from other countries or by creating new technology. Since DCs lack the technological capability to initiate technology, it is difficult to expect DCs to generate new technology internally without external help. If DCs are to narrow the technological gap by importing foreign technology, what are the main channels through which foreign industrial technology can be transferred to DCs?

VI. Main Channels for the Transfer of Technology

Main channels for the transfer of technology can be broadly classified based on the principal transfer agent involved as follows:

27 Maddison (1965, pp. 17-18).

28 OECD Observer (1968, p. 21).

29 Root (1968, p. 20).

- A. Transfer through individuals
- B. Transfer through private nonprofit organizations
- C. Transfer through official channels
- D. Transfer through multinational corporations.

A. Transfer through Individuals

History is full of examples of the diffusion of foreign technology through migration of people. We may distinguish between at least three types of migration—the individual, the group, and the minority.³⁰ The individual may be an artisan who brings with him new skills yet unknown to the local community or an entrepreneur who introduces either know-how or alien technology embodied in machines. Sometimes migration involves a group of persons in the same craft. They have an advantage over individual migrants in that they as a group might have developed organizational patterns effective for the performance of their work in addition to individual skills. For religious, political, economic, social, and other reasons, a whole community may move into a new society and carry with it a variety of skills and enterprises.

The transfer of technology through a migration of peoples from one society to another has some inherent limitations. First of all, success or failure of the transfer depends to a large extent on the readiness of the local community to admit foreigners and the ability of the newcomers to meet the resistance of vested interests in the local community. There are also legal barriers to overcome. Many DCs have very strict immigration laws. It is, therefore, unrealistic to anticipate that migrations on a large scale will take place from ACs to DCs. Even though migration is possible, the nature of modern industrial technology makes it less dependent upon this channel for its diffusion than is handicraft technology.

Aside from the channel provided by migration there are other channels for the transfer of technology on an individual basis. The principal transfer agents include students who have received training abroad, domestic merchants who have foreign contacts and whose business involves them in frequent foreign travel, the internationally-minded scientists, and foreign managers and technicians hired by the local enterprises.

Personal skills of these transfer agents can be transferred through this channel. However, there are some compelling reasons for the difficulty. First of all, these transfer agents are few in numbers. Qualified scientists, technicians, and managers are in short supply everywhere. It is very difficult for DCs to recruit them from a secure and promising career in ACs. Another limitation of this channel is the

³⁰ Scoville (1951, p. 349).

narrowness of the scope and depth of technology which can be transferred through personal skills of even very competent personnel. For example, corporate skills, in contrast to personal skills, cannot be transmitted through this channel.

B. Transfer through Private Nonprofit Organizations

Private nonprofit organizations such as research institutes, foundations, educational institutes, religious and other voluntary organizations provide a channel through which technology is transmitted to DCs. The Battelle Memorial Institute and the Stanford Research Institute in the United States are among the research institutes interested in the transfer of technology to DCs. These research institutes can provide modern technology on a confidential basis to their clients who lack their own research capability. The Ford Foundation and the Rockefeller Foundation are prominent among foundations active in transmitting technology to DCs.

The transfer of technology through various private nonprofit organizations has certain advantages over other channels. The objective of the organization's program is clearly stated and there are no political and other connotations which are often the case in official technical assistance programs. Nonprofit organizations do not seek equity interests as many multinational corporations do.

But there are also limitations. The type of technology transferrable through this channel is limited to primarily nonindustrial technology—agriculture, formal education, public health, etc., with an exception of the work done by research institutes. This is not to imply that this channel is not important. For in fact and in the long run, it can favorably affect the technological capability of a country by its concentrated emphasis on "institution-building." But the type of technology which is urgently needed in DCs, especially managerial skills, can hardly be transmitted through this channel on a large scale.

C. Transfer through Official Channels

Technology is transmitted to DCs through various official channels which fall within two categories, namely, bilateral and multilateral technical assistance programs. International organizations (UNIDO, UNDP, UNCTAD, etc.) have certain advantages which individual countries lack. First of all, technical assistance from multinational sources has no political connotation and, therefore, it faces little suspicion from DCs. International organizations can also benefit from a large scale of operation compared with small donor countries.

In spite of good intent and sincere effort, there has been a good deal of waste, duplication of effort and diversion of resources to low productivity projects. A number of reasons are given for this. First, since technical assistance is given on a grant basis, there is a tendency

for the recipient countries to view it as if no costs are involved when in fact substantial direct and indirect costs are required to accept such assistance. Second, there is a lack of coordinating machinery among aid-giving agencies. Third, some donors are eager to offer their services without adequate regard to the relevance of this assistance to priority development needs in DCs. Finally, there has been a relative neglect and lack of planning due to limited supplies of skilled and professional manpower.³¹ Much of the transfer of technology through official channels has concentrated on agriculture, education, and public administration through the provision of experts and the training of local personnel. In industry, however, the role of official technical assistance is necessarily limited. In fact, many donor countries and organizations are heavily dependent upon private enterprises in their effort to transfer industrial technology to DCs.

D. Transfer through Multinational Corporations³²

The ways technology is transferred to DCs through multinational corporations (MNCs) are many and varied, but they can be broadly classified into three categories:

1. Sale of goods and services
2. Various contractual devices
3. Direct investment.

1. *The Transfer of Technology through Sale of Goods and Services*

Technology is transferred to DCs by MNCs which sell goods and services. When goods, especially capital goods are sold to DCs, technical knowledge is transferred, for technology is incorporated in them. Sometimes technology is transferred through the sale of package industrial plants. This method of transmitting technology is commonly referred to as "turn-key" contracts which generally require the technology-supplying firm to design the plant, supervise construction, and train local personnel for plant operation. Technology is also conveyed to DCs by MNCs which sell services rather than goods. Consulting firms, international airlines and banks transfer technology through the sale of their services to many DCs.

The sale of machinery and equipment is the simplest vehicle for MNCs to transfer technology to DCs. However, much of complicated and sophisticated industrial technology cannot be transmitted to DCs without active participation of MNCs. Another principal obstacle to this channel is the governmental regulations restricting imports in order to conserve foreign reserves and encourage local manufacture.

2. *The Transfer of Technology through Various Contractual Devices*

31 OECD (1968, p. 9).

32 For a detailed discussion of the technology transfer through MNCs, see Oh (1970).

There are a broad variety of contractual arrangements under which technology is transmitted to DCs either independently or in conjunction with equity participation. These arrangements include among their most common forms:

- a. Technical service agreement under which technical information and services of technical personnel are made available by the MNC to its subsidiary or to an independent firm in a DC.
- b. License agreements under which the licensor grants to the licensee certain rights to make use of patents, trademarks, unpatented inventions, processes and techniques including secret know-how in connection with the manufacture and sale of products by the licensee in specified areas.
- c. Management contracts under which operational control of a firm that would otherwise be exercised directly by its board of directors or managers is invested in the MNC which may or may not have equity interest in it.
- d. Engineering and construction agreements under which technology relating to the design and construction of facilities required by a firm in a DC is made available to it by the MNC.
- e. Contracts for the exploitation of natural resources between the MNC and the DC under which the MNC makes available the technology required to carry out all or certain aspects of a program for the exploration and development of local natural resources.

The separation of various contractual devices into five categories is necessarily an arbitrary one. It is only useful for analytical purposes. In practice there are numerous combinations and variants. The transfer of technology through contractual devices has certain advantages. First, contractual devices can avoid trade barriers imposed on imports of goods. Second, since equity participation is not a necessary condition of the transfer of technology through this vehicle, there is no need for fear of "foreign domination" by the technology-supplying firms. Third, where there are governmental restrictions on the transfer of foreign exchange, "it has been found that the returns of royalties are often looked upon more favorably than the return of dividends and principal."³³ Finally, where the economy is centrally controlled and planned or where foreign direct investment is prohibited or limited, this channel may constitute the major alternative to other forms of the technology transfer.

There are also certain disadvantages. Most modern industrial technology is the result of team efforts within the firm which developed it. Its transfer and local application require the combination of a similarly wide range of skills and experience which many DCs lack. Thus, in many cases the performance of the technology-supplying

firm cannot effectively be reproduced by the independent firms in DCs without the active participation of the former. The willingness of the technology-supplying firm to share its technology with others is another limiting factor. For various reasons many MNCs are reluctant to enter into agreements with independent firms in which they hold no equity interest.

3. *The Transfer of Technology through Direct Investment*

Technology is transferred to DCs through direct investment by MNCs in a number of ways. Managerial and technical skills are transmitted by the transfer of personnel, the training of local personnel, and the assistance extended to local enterprises.

The fastest way of eliminating the shortage of qualified personnel in DCs is the transfer of managerial and technical personnel from ACs, for it takes time to develop needed skills among local personnel. The significant difference between expatriates sent by MNCs and those who have no corporate ties is that the former can transfer corporate skills as well as personal skills, but the latter can transfer only personal skills. Some corporate skills cannot be separated from the going concern and, therefore, expatriates working alone cannot transfer corporate skills. Effective transfer of corporate skills requires the presence of a going-concern.

Virtually all MNCs operating in DCs conduct training programs of one kind or another for local personnel. The training program may be formal or informal on-the-job training. It may be conducted at the individual plant or at a regional training center. High level personnel are most likely to be sent to the corporate headquarters located in one of the ACs. There is no doubt that local subsidiaries of MNCs are one of the best training centers for industrial skills in DCs and have much to contribute to the DCs.

MNCs generally extend technical and often managerial assistance to local suppliers, dealers, and other firms in the host country. Local entrepreneurs have a chance to see the modern factory firsthand by plant tours organized by MNCs.

For a variety of economic and political reasons, the transfer through direct investment by MNCs faces a growing resistance both in ACs and DCs. In ACs where most MNCs are headquartered, there is a growing view that the transfer of technology, especially sophisticated technology, by MNCs should be restricted to safeguard their own national economic interests. In DCs where MNCs have direct investments, MNCs are faced with a rising resentment and suspicion that these MNCs may dominate their local economy.

VII. **Conclusions and Policy Implications**

The essence of economic development is a rapid increase in

the economic productivity of nation. A number of factors are responsible for the increase in productivity and it is indeed difficult, if not impossible, to estimate from historical data the precise contribution of each factor to a nation's rate of economic growth.³⁴ Several conclusions can be drawn, however, from the empirical findings:

1. Empirical studies discussed above have presented irrefutable evidence to support the proposition that the increase in productivity in the United States and European countries studied has been largely a consequence of technological change, as contrasted with capital formation.

2. There is no justification for treating "residual factors" as exogenous, considering their overriding effect.

3. In the discussion of the growth model, emphasis should be shifted from the conventional inputs — capital, land, and labor — to the nonconventional inputs — training and education of labor, managerial and technical skills, research and development, etc.³⁵

4. The injection of new technology into an economy can accelerate the rate of economic growth and raise the standard of living.

5. The transfer of technology from ACs to DCs can help close the technological gap between ACs and DCs.

6. The transfer of technology through MNCs is one of the most effective means of transmitting modern industrial technology to DCs.

MNCs are the primary generators of modern industrial technology and they, like any other profit-oriented organization, are in business to make profits for their shareholders. Their investment decisions are influenced by so-called investment climate which is largely conditioned by the governments of the host countries where they invest. It is important for DCs to understand the motive and preoccupations of MNCs. DCs can take positive actions to encourage the technological transfer through MNCs and they include:

- Reasonably stable political and economic environment;
- Unambiguous attitude toward private enterprises, especially MNCs;
- Elimination of restrictive governmental policies and practices relating to import, licensing, and direct investment;
- Efforts to expand market opportunities through regional cooperation; and

³⁴ For some of the difficulties in interpreting the precise effect of technological change on the rate of economic growth, see Mansfield (1968, footnote 5, p. 5).

³⁵ Education and research have received particular attention in recent years by economists. For example, see Svennilson (1962, p. 6) in which he writes: "Education and research may thus be regarded as basic factors in a process of growth, while investment in capital equipment may be relegated to the role of a necessary by-product of this process." *Ibid.* For a discussion of the nonconventional inputs, see Campos (1967, pp. 62-63).

– Improvement in the local technological capabilities.

If collaboration between DCs and MNCs is to be attained, it can hardly be achieved by seeking forcibly to subordinate the interests of one side to those of the other. Since each is free to accept or reject such collaboration, there can be no compulsion. Where both agree that they need each other to achieve their admittedly divergent objectives, there must be a basis for reconciliation to the mutual benefit of all concerned.

Extensive research is clearly required to study the role of technology in economic development of DCs, and the conditions and procedures under which industrial technology of ACs can effectively be transferred to DCs at reasonable costs. It is hoped that the present paper is a small contribution toward that goal.

References

- Abramovits, M., "Resource and Output Trends in the United States Since 1870." *American Economic Review*, 46:2 May, 1956.
- Advisory Committee on Private Enterprise in Foreign Aid, *Foreign Aid through Private Initiative*. Chairman's Summary, A. K. Watson, Chairman. Washington, D.C.: AID, 1965.
- Agency for Science and Technology (AST), Japan, *Science and Technology White Paper*. Tokyo: Government Printing Office, 1975.
- Alexander, B. C., "Indigenous Private Enterprise in Developing Countries." *Motivations and Methods in Development and Foreign Aid*. Proceedings of the Sixth World Conference of the Society for International Development. Washington, D.C., March 16-18, 1964. Edited by T. Geiger and L. Solomon. Washington, D.C.: The Society, 1964.
- Bachman, H., *The External Relations of Less-Developed Countries*. New York: Frederick A. Praeger, 1968.
- Baranson, J., "Transfer of Technical Knowledge by International Corporations to Developing Economies." *American Economic Review*, 56:2 May, 1966.
- Behrman, J.N., "Advantages and Disadvantages of Foreign Licensing." *Patent, Trademark, and Copyright Journal of Research Education*, 2.1 March, 1958.
- Campos, R. de Oliveira, *Reflections on Latin American Development*. Latin American Monographs, No. 8, Institute of Latin American Studies. Austin, Texas: University of Texas Press, 1967.

- Dension, E. F., *Why Growth Rates Differ: Postwar Experience in Nine Western Countries*. Washington, D.C.: The Brookings Institution, 1967.
- Eckaus, R. S., "Notes on Invention and Innovation in Less Developed Countries." *American Economic Review*, 61:2 May, 1966.
- Fabricant, S., *Economic Progress and Economic Change*. Thirty-Fourth Annual Report of National Bureau of Economic Research, Inc. New York: The Bureau, 1954.
- Gill, R. T., *Economic Development: Past and Present*. Foundation of Modern Economics Series. 2nd ed.; Englewood Cliffs, N.J.: Prentice-Hall, 1967.
- Hagen, E. E., *On the Theory of Social Change*. Homewood, Ill.: Dorsey Press, 1962.
- Leontief, W., "The Economic Impact." *Automatic Control*. Edited by Scientific American. New York: Simon and Schuster, 1955.
- Maddison, A., *Foreign Skills and Technical Assistance in Economic Development*. Paris: OECD, 1965.
- Malada, G. S., and Knight, P. T., "International Diffusion of Technical Change: A Case Study of the Oxygen Steel Making Process." *Economic Journal*, 77:207 Sept., 1967.
- Malenbaum, W., "The Asian Economic Potential." *Annals of the American Academy of Political and Social Science*, 318 July, 1958.
- Mansfield, E., *The Economics of Technological Change*. New York: W. W. Norton & Co., 1968.
- Massell, B. F., "Another Small Problems in the Analysis of Growth." *Review of Economic and Statistics*, 44:3 Aug., 1962.
- Massell, B. F., "Capital Formation and Technological Change in the United States Manufacturing." *Review of Economic and Statistics*, 42:2 May, 1960.
- Meade, J. E., *A Neo-Classical Theory of Economic Growth*. Rev. new ed.; London: George Allen & Unwin, 1962.
- Merril, R. S., "The Study of Technology." *International Encyclopedia of the Social Sciences*. Edited by D.L. Sills. New York: Macmillan Company, 1968.
- Ministry of Science and Technology (MOST), Republic of Korea, *Handbook of Science and Technology*. Seoul, Korea. 1974.
- National Commission on Technology, Automation, and Economic Growth, *Technology and the American Economy*. Vol. 1; Washington, D.C.: U.S. Government Printing Office, 1966.

- Nurkse, R., *Problems of Capital Formation in Underdeveloped Countries*. New York: Oxford University Press, 1960.
- OECD, *Technical Assistance and the Needs of Developing Countries*. Paris: OECD, 1968.
- Oh, Moonson, *The Role of International Corporations in the Transfer of Technology to Developing Countries*. Unpublished doctoral dissertation, University of Pennsylvania, 1970.
- Ray, G. F., "The Diffusion of New Technology: A Study of Ten Processes in Nine Industries." *National Institute Economic Review*, 48 May, 1969.
- Root, F. R., "The Role of International Business in the Diffusion of Technological Innovation." *Economics and Business Bulletin*, 20:4 Summer, 1968.
- Schultz, T. W., "Investment in Human Capital." *American Economic Review*, 51:1 March, 1961.
- Schumpeter, J. A., *The Theory of Economic Development*. Cambridge, Mass.: Harvard University Press, 1934.
- "A Scientific and Technical Policy to Facilitate and Accelerate the Dissemination of Knowledge." *OECD Observer*, 33 April, 1968.
- Scoville, W. C., "Minority Migrations and the Diffusion of Technology." *Journal of Economic History*, 11:4 Fall, 1951.
- Solow, R. M., "Technical Change and the Aggregate Production Function." *Review of Economic and Statistics*, 39:3 Aug., 1957.
- Solow, R. M., "Technical Progress, Capital Formation, and Economic Growth." *American Economic Review*, 52:2 May, 1962.
- Svennilson, I., "What Makes an Economy Grow?: The Role of Research and Education." *OECD Observer*, 1 Nov., 1962.
- "Technological Gaps: Their Nature, Causes and Effects." *The OECD Observer*, 33 April, 1968.
- Thomas, D. Babatunde, *Capital Accumulation and Technology Transfer: A Comparative Analysis of Nigerian Manufacturing Industries*. New York: Praeger, 1975.