TRANSFER OF TECHNOLOGY: ISSUES AND POLICIES*

S.M. Wangwe**

1.0 INTRODUCTION

Technology is here identified as hardware of production (knowledge about machine and processes) and software (skills, knowledge and procedures of performing practical tasks). As pointed out by Cooper (1972), technology involves not merely the systematic application of scientific and other organized knowledge to practical tasks but also the social and economic atmosphere within which such application has to take place

The less developed countries (LDCs) seem to believe that they could make great jumps in production by using technologies which had already been developed in the advanced countries Such transfer of technology would permit LDCs to use high productivity techniques without themselves going through the difficult and costly process of designing, testing and developing them. These expectations were partly encouraged by experiences in the 19th century where technology was successfully transferred from Britain to the USA and Germany. Bhatt (1975) has clearly discussed the ways in which the technology problem currently differs from that faced by the 19th century developing countries.

The dependence of the current LDCs on technology from advanced countries is evident from the high ratio of imported technology to the production needs of the LDCs. the need to import this technology in the absolute sense. and the one-way flow of technology without the ability to engage in its exchange. The effects of this unsatisfactory relationship with advanced countries have generated concern in the LDCs. These effects are briefly surveyed in section two as the main issues in transfer of technology today. In section three the possibilities of developing a local technological capacity are considered.

2.0. MAIN ISSUES IN THE TRANSFER OF TECHNOLOGY

Transfer of technology has been associated with various problems in LDCs. The form that transfer of technology has taken from the advanced countries to the LDCs has largely deprived the latter of autonomy in decisions. The structure of the market for technology is such that the LDCs are the losers and the technologies acquired from advanced countries are not suitable in one way or another. To these issues we now turn.

2.1 LACK OF AUTONOMY IN DECISIONS

The fact that the decisions about choice of technology in LDCs are usually made by the advanced countries has raised concern. This concern is even more justified when lack of autonomy in technological decisions results in lack of autonomy in most of the determining variables (e.g. investment, prices, sales, purchases)

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** Senior Lecturer, Department of Economics, University of Dar es Salaam.

Lack of autonomy in decision making is most glaring in cases of private foreign investments. The foreign investor will tend to choose technology which is most familiar to him and this will normally be from his country of origin. If the enterprise is a subsidiary of the multinational company, the choice of technology is conditioned by the international character of their technological activities and the necessity to standardize technological activities across borders. In addition to this control over technological decisions, the foreign investor controls all other decisions which are normally taken at enterprise level. These include, for instance, decisions on amount and nature of investment, prices, output, source and nature of inputs, quantity and destination of output and allocation of profits.

One reason for the emergence of joint ventures is the desire to have access to the decision making process with respect to some of the crucial variables that are determined at enterprise level. Even in joint ventures, Subramanian (1972) finds that in India foreign firms have managed to dilute ownership-mix in such a way that they remain in control. UNCTAD (1975) attributes this phenomenon to the existing asymmetry of technical knowledge and skill; especially for skills that come mostly from practice and learning by doing.

In the light of the results from both foreign investment and joint ventures the LDCs have in some cases opted for total local ownership so as to have total control over all enterprise level decisions except probably those which are specific to technology bought from abroad. As a consequence of lack of sufficient technical know-how these totally locally-owned firms plunge themselves into technical management agreements and or licensing agreements. The import of foreign technology somehow includes clauses determining variables such as: source of machinery and other inputs, spare parts, prices, output, exports, restrictions on local research and development (R & D). The findings by Sercovich (1974) in Argentina, Subramanian (1972 in India, and Kuuya (1977), Coulson (1972, 1977), and Baregu (1978) in Tanzania show that most of the power of independent decision making is taken out of the hands of the local ownership and management.

2.2 THE STRUCTURE OF THE MARKET FOR TECHNOLOGY

Modern industrial activities tend to be highly specialized. Such specialization in technological activities is sufficient to allow a degree of appropriation by individual firms to the exclusion of their competitors or of new entrants. Successful appropriation of technology attributes a market value for technology. The sheer volume of technological information, the fast rate at which it grows and the high degree of specialization in its generation and use in world industry cause imperfections in its supply. In fact even where different techniques may be available in the technology market the process of merely finding out what alternatives exists is costly. The buyer may not be willing to incur these search costs beyond reasonable limits.

The system of commercialization of technology has permitted quasi-monopolies in the technology market hence the sale of technology at a high price. UNCTAD (1972) has estimated the direct costs involved in overt technology transfer. The estimated costs of payments for patents, licenses, knowhow, trade marks and technical fees were $1500 million in 1968. These figures exclude costs of technology inherent in under-invoicing and over-invoicing of goods and services and the payment for foreign personnel. In addition to these direct costs there are also indirect costs which take many forms. Probably the most common is that of tying the purchase of imported inputs, machinery and spares to a particular source. Other indirect costs arise from the restriction of exports, limitation of competing supplies, discouragement of use of local personnel and last but most important is the discouragement of generating local technological capabilities. The technology suppliers making transactions in technology in favour of the more informed party exploit the quasi-monopoly situation through simple direct sales of technology, process packaging and even project packaging.

2.3. INAPPROPRIATE TECHNOLOGY

The issue here is that imported technologies may not be suitable for the LDCs environments. Rosenberg (1976) indicates clearly how the history of technological development shows that new techniques and processes were developed in particular industries and in particular environments. The technologies which have been developed in the advanced country structure of resources and environmental factors may not necessarily be suitable for the LDCs structure of resources and environment. The imported technologies may be inappropriate with respect to scale of production, resource use, climatic conditions and consumption technologies.

2.3.1 SCALE OF PRODUCTION

In advanced countries technologies have become increasingly large scale and increasingly specialized. Stewart (1977) clearly illustrates the increasing size of firms and plants in recent years in the U.S. and U.K. This increasing scale encourages technical changes designed for the new forms of organization, so that they can only be operated by large and specialized units. In fact Worley (1962) demonstrates that large firms account for a more than proportionate share of research and development, devoting it to technology suited to large scale production.

Stewart (1977) shows that with much lower income per capita, the size of the market in most LDCs is only a fraction of that of the U.K. market. Thus even those industries which are efficient at a relatively small scale in advanced countries, are large in relation to LDC markets. As a result in many lines of production one plant is often more than sufficient to cater for the entire market. Production therefore tends to be monopolistic and centralized. In the case of Tanzania, Wangwe (1977) has argued that this is one of the causes of excess capacity to be found in manufacturing. For instance under-utilization of capacity in Mara dairy plants, Steel Rolling Mills, Metal Box and the General Tyre is of this type. The small markets are fragmented further by the inadequate conditions of transport. An inadequate transport network or a low capacity to distribute goods in the whole economy may call for small size plants to be spread in the country. In this sense large scale technologies usually turn-out to be even more inappropriate e.g. in Tanzania cement production centralized in one plant has left many areas up-country without cement.

2.3.2. RESOURCE USE:

The appropriate technology is partly identified in relation to the types of resources which the technology uses. These resources include labour, machinery and material inputs.

Rosenberg (1976) argues that the development of technologies has tended to economise on expensive resources. The type of technologies developed in a county largely reflects the structure of resources available in the country. Since the LDCs hardly develop their own technologies they often have no choice but to use those technologies which have been developed in the advanced countries. Such technologies are more in line with the advanced country structure of resources than with the resources in the LDCs.

Technologies imported from the advanced countries and used in LDCs have often been capital intensive. This is appropriate in high-income countries since a high investment per head can be afforded. In capital scarce LDCs, the use of capital intensive technologies does not reflect this scarcitv.

Techniques designed in the advanced countries have assumed high levels of labour skills and literacy at all levels. This is in line with the vast growth in educational and training expenditure in those countries. Lack of such a high level of education and training in LDCs necessitates the importation of skilled manpower along with the hardware part of technology.

Advanced country techniques usually require inputs from the advanced countries. In fact Stewart (1977) argues that there are all sorts of links between different techniques. In some cases the technique requires inputs of a particular quality and specification. Kuuya (1977) shows this clearly in the case of cement and other industries and Coulson (1977) shows this in case of the fertilizer company in Tanzania.

2.3.3. CLIMATIC CONDITIONS

Differences of temperature, humidity and seasons lead to differences in natural vegetation and in conditions of production. These differences affect agriculture most and attempts to transfer agricultural techniques unmodified are likely to fail. These climatic differences are also capable of affecting processing, manufacturing and construction technology.

2.3.4. CONSUMPTION TECHNOLOGIES

Studies of the history of technological development in America and Britain in the 19th century point to the importance of the composition of consumer demand and the malleability of consumer tastes of production technology. Final product innovations required some innovations in the production technologies. Production technologies, particularly in Britain were shaped to meet consumer tastes as indicated by Rosenberg (1976). The consumer demand in such advanced countries is a function of cultural and economic factors. On both counts the underdeveloped countries differ substantially from the advanced countries whose production technologies presuppose certain patterns of consumer demand i.e. consumption technologies. In this sense, choice of production technology is to varying degrees choice of product by type and/or quality and vice versa.

In fact a main charge against import substitution industrialization is that it has concentrated on wrong products in that they embody technological characteristics that are either unnecessary, undesired or too costly e.g. nylon shirts are uncomfortable in heat yet they are produced and put on in the tropics, maize milling in complex automatic rollers while removing much of the nutritious content are less appropriate than the hammer mills which they replace as Stewart (1972) has demonstrated.

The foreign technologies may therefore have been developed to suit foreign consumption patterns yet the very process of importing these production technologies carries along the consumption technologies which they embody.

It should also be noted that international trade also supports this tendency because a country must offer internationally acceptable standards of manufactures to compete in international markets.

3.0 STRENGTHENING THE LOCAL TECHNOLOGICAL CAPACITY

The brief summary of the main issues in the transfer of technology points out that there is need for an approach requiring policies at two interrelated levels. One set of policies would seek to establish a new set of international norms to bring about a more equitable sharing of the benefits between the underdeveloped countries and the developed countires from the transfer of technology. This set of policies is usually covered under the international code of conduct and the revision of the industrial property system. The other set of policies would have the aim of strengthening the capacity of the underdeveloped countries to acquire, use, adapt and generate technology that meets their needs. This section deals with some aspects of this second set of policies.

3.1. THE ENGINEERING SECTOR AND LOCAL TECHNOLOGICAL CAPACITY

That an underdeveloped country lacks autonomy in decisions referring to technology is due to the fact that a large proportion of production techniques in use is acquired from advanced countries. This is bound to be the case because while the advanced countries have the capacity to generate production techniques the underdeveloped countries lack this capacity largely because of the absence of capital goods sector which is responsible for generating technology primarily in the form of capital equipment and machinery. In fact McLean and Round (1978) have found that the producer goods industries are relatively more innovative than the other industries. In addition, the producer goods industries show the closest links between R&D inputs and product innovativeness. Lack of autonomy in technological decisions is not a deliberate option by an underdeveloped country rather it arises from the underlying structure of production in these countries.

That the world market for technology is monopolistic and advantageous to the seller follows from the fact that the seller has the capacity to produce the technology while the buyer does not have this capacity. Technical knowledge is not readily available and technology is effectively appropriated to some degree in nearly all cases. Under the capitalist economies it is this exclusion and appropriation which

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leads to quasi-monopolies whose superprofits act as an incentive for industrial innovation. Cooper and Hoffman (1977) argue that the existence of an international market for technology implies that Paretian optimality in the production and use of technology in the world economy is strictly unattainable. They conclude that national LDC governments have to intervene in transfer of technology. One form which such intervention could take is the development of local technological capabilities by developing the engineering industries. These can be responsible for generating local technologies and adapting foreign technologies to local conditions.

The use of inappropriate technology arises because this technology has been developed in a different environment to solve a different set of problems. The techniques were developed and perfected in response to the demands of specific customers. The experience of the advanced countries shows that physical proximity between the producer and the user of machinery seems to have been indispensable for reasons rooted in the problem of communication as has been indicated by Rosenberg (1976). Successful technological development seems to involve a kind of interaction that can best be provided by a direct confrontation between the user of a machine and the producer who is thoroughly versed in problems of machinery production and who is alert to possibilities of reducing machinery costs. This requires that producers of machinery and the users of these machinery be in the same environment. However in a country like Tanzania we have users of machinery but we don't have any significant number of producers of machinery. The root cause of the use of inappropriate technology therefore primarily lies in the production structure and only secondarily in the bad choice of imported technology.

The little experience Tanzania has had in the manufacture of capital equipment indicates that although in most cases the designs were copies from some imported models the interaction between users and producers of these technologies has resulted in modifications to make the technologies more appropriate. Cases in point are the manufacturers of hammer mills and farm implements who have made a number of modifications in the light of the customers' response and the environmental factors. The interaction between engineering and the user of technology appears to be closer when the engineering activity (i.e. central workshop) is attached to the user of technology (i.e. the main plant) as Collande and Wangwe (1977) have argued.

The interaction between the user and the producer of technology cannot be expected to occur so long as almost all production technology is imported from the advanced countries. The users of technologies in a country like Tanzania cannot influence the decisions of the producers of production technologies in the advanced countries. After all about 98% of current R & D efforts takes place in advanced countries and the LDC's market for machinery is too small to influence the machine manufacturers in the advanced countries (Stewart 1977).

New techniques frequently require considerable modification before they can function successfully in a new environment. This process of modification often involves a high order of skill and ability which is typically underestimated or ignored. Yet the capacity to achieve these modifications and adaptations is critical to the successful transfer of technology – a transfer which is erroneously thought to be a matter of transporting a piece of hardware from one location to another. The ability to undertake modifications and adaptations of technology requires facilities on which to work. The creation of a capital goods sector is regarded here as the creation of an important aspect of the facilities on which modification, adaptation and generation of technology can take place.

3.2. THE ENGINEERING SECTOR AND LEARNING–BY–DOING

A major reason for a domestic capital goods industry is that the ability to utilize complex machinery effectively whatever the country of origin of the machinery depends on the kinds of skills which such an industry uniquely makes available. Many of the technical skills however are acquired through direct on–the–job participation in the work process. Since this includes a large component of uncodified skills, such skills cannot be transferable easily through formal education. In this case learning–by–doing becomes crucial to the acquisition of those skills.

Arrow (1962) has proposed that the installation of capital equipment provides the vehicle for learning in the economy to the extent that a cumulative gross investment has been made the measure of experience. It should be noted that this proposition holds only if installation of capital equipment is accompanied by the experience to manufacture the capital equipment and the transfer of this skill to the users of the equipment. It is in view of the crucial role of learning by doing that Rosenberg (1976) argues that the history of the advanced countries shows that where transfer of technology involved places geographically distant from one another, the reliance upon migration of trained and or experienced personnel (at lieast temporarily) was very strong.

Learning by doing is in this case a process of interplay between men and machines rather than the passive comformity of the ordinary agents of production to rules and systems laid down by some foreign developers of technology. The learning process of this type cannot be attained in the absence of a sector manufacturing machines (at least as regards the technology of making and or modifying machines).

Experiences elsewhere support the hypothesis that on–the–job training is an indispensable complement to formal training particularly in the engineering sector. In his study of Soviet metal fabricating, Granick 1967) shows how the government invested heavily in formal technical training in the first five year plan yet by 1933 it was clear that on the job training had to be accepted as a complement to formal education. Even the observed tendency to increase the man-machine ratio was intended to maximize on–the–job training. In the case of Brazilian capital goods industry Leff (1968) has shown that the industry increasingly became more skill intensive and more than 50% of skilled workers acquired skills through on–the–job training. A study of the engineering industries in Tanzania (undertaken by the author) reveals that shortage of manpower skills seems to be more critical in the activities which have been introduced into the sector very recently e.g. moulding, steel casting and pattern-making. All these findings show that the learning effects acruing from the establishment of engineering industries are substantial. It is not enough to talk of scientific and technological manpower development without focusing on the establishment of industrial activities which made significant contribution to technological and innovative skills.

3.3. THE ENGINEERING SECTOR AND SCIENTIFIC INSTITUTIONS

In order to strengthen the local technological capacity it is necessary to strengthen the R & D activities and scientific institutions. It has been noted by Herrera (1972) that the scientific institutions in the LDCs are not only weak but they are also alienated from production activities. Often the scientific institutions are involved in research activities which are not closely linked to the production activities in the LDCs. Even when these institutions do research and recommend the types of technologies required it still requires that the recommended technologies be generated To generate such technologies is possible if the production capacity for machinery and equipment (the hardware) exists. In its study of the Colombian engineering industries the Bogota Institute of Technological Research (1975) argues that as a result of lack of communication between manufacturers of agricultural equipment and research institutions, designs and prototypes are not being taken up for commercial production. In the case of Tanzania the agricultural machine testing unit at Arusha designs, develops and tests the prototypes. These prototypes have not been taken up for production by manufacturers like the Ubungo Farm Implements Ltd partly because of lack of coordination and partly because of an insufficient productive capacity on the part of manufacturers of farm implements. These findings demonstrate that the collaboration of the research institutions with the whole productive system cannot be complete in the absence of a fairly developed engineering sector.

.4. CHOICE OF TECHNIQUES AND THE TRANSFER OF TECHNOLOGY

No doubt in the absence of a strong technological capacity the choice of techniques from other countries will be very limited. More often than not the use of inappropriate technologies may not be avoided. However, it is recognized here that of the limited range of techniques that exist in advanced countries some are less inappropriate than others. We note that in baking, for instance, one can choose manual, mechanical or automated technology. In textiles one can choose technology of the Mwatex type, the Friendship type, the Kiltex type etc. The choice is limited but the choice matters.

David (1975) has observed that technological learning depends upon the accumulation of actual production experience. Short sighted choices of techniques in effect govern what subsequently comes to be learned. Choice of technique become the link through which prevailing economic conditions may influence the future dimensions of technological knowledge. For instance, an automated technology may require very little operation skill besides switching a few buttons. The technological learning by the operators may remain minimal even after many years of experience. The technological learning effect partly depends on the type of technique chosen To the extent that technological learning takes us nearer to effective transfer of technology, choice of techniques which possess potentials for learning effects are more desirable.

Cooper (1973) has argued that in the underdeveloped countries there is very little demand for local engineering goods and services. The imported technologies tend to generate demand for further imports of technology in the form of components and spare parts and even maintenance and repair. This puts an obstacle on the development of a local engineering capacity. However, the extent to which this factor operates in practice varies with the kind of technology imported. In the bread-making industry in Tanzania, the bakeries which are simply mechanized seem to obtain many of their parts and components locally from the existing engineering firms. This is contrary to the case of the automated bakery where parts and components are too sophisticated to be manufactured locally. The use of the latter technology therefore exerts relatively less (if any) demand for the local engineering products. At the Urafiki Textile mills a larger proportion of parts can be made locally than the case is for Mwatex, for instance. Even in the same industry it can be observed that the type of technique employed may generate more or less local demand for engineering products. A decision to develop an engineering sector therefore needs to be accompanied by a decision to choose production techniques which can generate demand for local engineering products.

Scale and length of production runs may be an important variable in developing the engineering sector to the extent that below a certain level of scale or length of production runs it may be too costly to manufacture certain equipment locally. On this variable, choice of techniques may exert an influence. The more the production techniques are standardized the more economic the production of components is likely to be. For instance, it would not be possible to manufacture homogeneous sets of looms or parts for all our textile mills because several different technologies have been chosen for the textile industry. The decision to go into the manufacture of looms would be made relatively simpler if at least many of our mills were using not too different technologies. In fact, the failure to implement a proposal to manufacture motor vehicle spare parts in Tanzania has been partly attributed to the heterogeneity of motor vehicle models that are in use in the country. Choice of technology in the transport equipment has therefore contributed to block the establishment of a spare parts manufacturing activity. When the importance of standardization is cited in connection with the strengthening of the technological capacity it should be realized that choice of techniques has a role to play.

The choice of techniques is already limited but it will be limited further if the consumption technology continues to be rigid and imitative of the foreign consumption patterns erroneously thought as "ideal" and "international" standards. For example, as shown by Stewart (1977), choice of highly refined white maize flour already rules out the hammer mill as an alternative technique of production, one has to use a complex technology (the roller mill). Whereas the hammer mills can be manufactured locally, roller mills have to be imported. Therefore the choice of highly refined maize flour amounts to choices of roller mills i e. generates demand for a technology which has to be imported and deprives the local munufacturers of hammer mills the chance to develop. Another example can be cited in the sugar industry. Of the two techniques i.e. vacuum pan and open pan, the quality of sugar refined under the vacuum pan technique is "higher", it is whiter and finer. Sugar obviously meets need of sweetening food whether it is white, brown or yellow. The consumer, however, may have been used to a consumption technology of white fine sugar in which case not so white and fine sugar may not be tolerated. This means that the open pan technique is no longer an alternative. The open pan technique can produce at smaller scale (plants can be scattered in districts), the machines used are simpler and Baron (1975) noted that open pan sulfitation units in Uttah Pradesh (India) stimulated local machine building industry. Choice of white and fine sugar requires a vacuum pan technique which is complex and does not generate demand for the local manufacture of machines for the sugar industry.

4.0. CONCLUSION

It has been argued, in this artiele, that the problems of transfer of technology are largely a result of the wide technological gap that exists between underdeveloped and advanced countries. The former have such a low technological capacity that they cannot adapt, modify, and absorb imported nor can they generate their own technology. This is unlike the 19th century situation where the technological gap between the U.K. and importers of technology like the US and Germany was not very significant. While the solution could be tackled at the international front at least to prevent the worsening tendency of the world market for technology it is argued here that the primary solution lies in the solutions at the national level. This is backed by the fact that while the LDCs seem to advocate an international code of conduct, which would legally bind the technology transfer activities, the advanced countries seem to favour a voluntary arrangement since most of their technology is privately owned. It is, recognized that there is need to strengthen the technological capacity at national level (where appropriate, at interregional level). One way of strengthening the technological capacity at national level has been discussed in this paper i.e. developing the engineering soctor. This discussion is made on the understanding that most of the imported technology is embodied in machinery and equipment. Production of machinery and equipment therefore is seen as a significant step towards creating a base for adapting and absorbing foreign technology and generating local technology. It is here that effective transfer of technology has to begin.

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