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Technological dependence in Africa: its nature, causes, consequences and policy derivatives

J.A. Fabayo
Department of Economics, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract

Technology is critical to development because it is a resource which endows economic growth with much of its capacity for satisfying human wants. Whether the need is for more food, better education, improved housing, health care, transportation and telecommunication, increased industrial output, etc., modern technology plays a decisive role, particularly as it enhances the efficiency of resource utilization, spurs the creation and expansion of resources (e.g. physical capital) and diminishes the importance of natural factor endowment in economic progress. It is this developmental role of technology that makes its acquisition or the capability for generating it important and underscores the need for its importation in Africa, given the continent's inability to source it locally.

It is, however, the contention of this study that African countries' reliance on technology imports has not only inhibited local technological development efforts in the continent, but has also contributed, in a rather cumulative manner, to the distorted development or underdevelopment of the African economy. Unless concerted efforts are made to build up a strong indigenous scientific and modern technological development capability that can guarantee some degree of self-reliance in technological matters, any hope for a rapid and internally stimulated development of the African economy will remain as a mere illusion. Copyright © 1996 Elsevier Science Ltd

1. INTRODUCTION

In almost every respect, the African economy is dependent on the developed industrialized countries for sustenance, for the purchase of vital inputs for agricultural and industrial production, for markets for the sale of its primary products and supply of its manufactured goods, and even for the food that is needed to sustain life in some areas on the continent. It is a satellite economy.

An important reason for this African situation, and for its low level of development in particular, is that the continent lacks a strong indigenous scientific and modern technological development capability. It is almost a truism that the level of development of any society is directly correlated with the level of (appropriate) technology available to it. This is because no matter the way we look at technology, whether as an artefact (embodied technology) or applied scientific knowledge (software technology), or the totality of the means employed by man to provide himself with the objects of material culture, it is a critical variable in any mode of production and therefore an important motive force for development.

For example, technology has played a major part in raising the world's productive capacity, accelerat-

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ing the growth of output, improving standards of life, most especially in the developed countries (DCs), and in spreading modernization. By providing more machinery to aid the worker, it has enabled him to produce more with less effort, whether it is in the factory or the fields. This is particularly so in the DCs where technological advance is known to have accounted for a substantial rise in output per man-hour (Fabrican, 1954; Jogenson and Griliches, 1967; Solow, 1957). In fact, there is no developed country in the contemporary world in which the application of modern technologies on a wide and systematic scale has not been fundamental to revolutionizing productivity in agriculture, industry and all the economic and social services.

By creating wealth (e.g. through trade in technology) and making factor inputs more efficient, technology brings affluence and provides the lubricant in the wheel of economic progress. It is therefore inseparable from the processes of resource creation, increased productivity of input use, capital accumulation and economic development and growth.[1]

This developmental role of technology makes the acquisition and command of technology of crucial interest to all countries, especially the less developed ones (LDCs) which are still unable to exercise real choice in designing effective strategies for their technological transformation and whose underdevelopment derives partly from their lack of it. The incapability of the African continent, like the other developing regions of the world, to source needed modern technological resources for development locally, coupled with the way the international system operates, has made dependence on offshore sources inevitable.

It is, therefore, the objective of this paper to analyse, from the African perspective, the nature of technological dependence in Section 2, the causes of it in Section 3, its consequences in Section 4 and its policy derivatives or implications in Section 5.

2. THE NATURE OF TECHNOLOGICAL DEPENDENCE IN AFRICA

Reliance on imported technology is described as technological dependence. It arises either because of specialization and trade in technology or because of the absence of internal capability to produce needed technological resources on the part of a country, a weakness that then necessitates technology importation, or as an aspect of the general pattern of dependence resulting from the operations of the international economic system and the institutions and mechanisms that govern the relations between the DCs and LDCs.

Technological dependence can be mutual or asymmetric. Technological dependence of one country on another in the sense of mutual reliance arises when a country both imports and exports technology; that is, when a country imports some foreign technology to complement the technological resources locally available to it for development while, at the same time, the country has attained an internal technological development status that makes it possible to generate technology for exports. This is the case, for example, in the technologically advanced market economies. These countries specialize and trade in technologies, importing and exporting technologies as it were.

In this case and in most of these countries, imported technologies constitute only a small fraction of the total technological requirements needed for development. In countries like Canada, Japan and New Zealand where the proportion may be relatively high, the flowering of imported technology is often fast because there already exists a dynamic internal technological base on which imported technology is or can be erected.

Two things should therefore be mentioned about the conditions of technological dependence in the mutual sense. First, technology is not usually imported and used wholesale and indiscriminately. Rather, it is selected, adopted, modified and fitted smoothly and productively into an already developed domestic technological system. This way, local technological capabilities are nourished. Second, it enhances technological interdependence which may facilitate prosperity through specialization, which makes for a more efficient allocation of technological resources and increases the returns to these resources.

By contrast, technological dependence of the asymmetric type is characterized by a one-way relation and represents a situation when a country can import but not export technology. It occurs when a country continuously and systematically imports almost all its technology from abroad. This happens when a country does not have the local capability to produce most of its technological needs which are then invariably sourced from outside, particularly in a subordinate manner which is interlocked with the way the international economic system is constituted.[2]

Under conditions of asymmetric technological dependence, imported technologies are adopted wholesale without any local modification, adaptation or assimilation because the capability to do so is not there. In this case, rather than the imported techno-

[1] As evident by the experiences of the DCs and the long march to present-day development which has brought mankind the steam engine, the windmill, the handloom, the automobile, the computer, the aeroplane, and space exploration.

[2] The international economic system is a stratified system of power relations. Because it has a structure that helps to determine who decides and who controls, it is a system of domination.

logies supporting local technological development, they substitute for it. The technological situation in the LDCs takes this form of dependence,[3] particularly in their modern or formal sectors where activities are organized broadly on the basis of imitating those of the DCs.

Incidentally, it is the asymmetric form of technological dependence that is of central concern in economic development, presumably because of its seriousness as it applies to the prospect for development in the LDCs, and also because of the need to restructure the international economic system that tries to perpetuate it. For example, it is perceived as a source of domination and exploitation (of the LDCs by the DCs, of the poor by the rich) in international relations and consequently of underdevelopment or distorted development within the LDCs.

Africa's technological dependence (ATD) is of the asymmetric type in which the knowledge about many production processes, the techniques and organization of production, especially in Africa's modern sector, derive essentially from the external connection. ATD manifests itself in various distinct though highly interrelated forms, the most important of which relate to technological dependence in production, consumption and organization or management. Of course, these are the important dimensions of technology, which has been defined as the knowledge, skills, methods and procedures associated with the production and utilization of goods and services in a given society (Girvan, 1979, p. 1).

Production technology relates to the techniques of production, i.e. things pertaining to the transforming of inputs into outputs, the meaning of the term technology in ordinary usage. Africa's dependence in this regard reflects the inability of the continent to generate a spirit of scientific enquiry that is closely related to modern processes of production. The situation is even worsened by the lack of local capability to modify imported production processes to suit African circumstances or to innovate on them in response to the internal dynamics of development in the continent.

Consumption technology relates to the choice of products for the satisfaction of specific consumption requirements. It therefore defines the mix of goods and services which the production technology has to deliver (Girvan, 1979, p. 1). And as we shall see later, this has a feedback effect on the maintenance of technological dependence in consumption.

Organization technology provides the framework within which production technology is selected and applied and its fruits distributed socially; it affects and is affected by other aspects of technology as well.

3. THE CAUSES OF TECHNOLOGICAL DEPENDENCE IN AFRICA

Irrespective of how we look at it, the technological situation in Africa today is one of entrenched dependence. Yet, the trend curve of technological development in the continent shows that it was not so at the beginning and, given the challenges that independence and the demands of Africans for a better living have raised, it is not desired to remain so.

For example, it was in Africa that the earliest man-made tools were developed (Hamilton, 1973, p. 19) and some of the first wonders of the world like the pyramids of Pharaoh were built (ECA, 1984, p. vi). It was also in Africa that, many thousand years ago, man produced wealth in abundance by using his powers of imagination, his mastery of science and his invention of technology to irrigate, grow and store food, to build boats or canoes, to manufacture and to extract mineral resources from the subsoil (ECA, 1984; Hamilton, 1973). In this cradle of civilization and technology, Africa has its place, thus belying some conventional development economists' 'original condition hypothesis'[4] with respect to Africa's technological and general underdevelopment.

But in spite of these positive beginnings and of the modest progess sustained by ancient Africans' minds, Africa has today been left in poverty in innovative ideas, creativity and material wellbeing. The factors that have relegated Africa to the background, to the position of dependence, particularly in the crucial area of modern technology, are diverse but not far fetched; they are both external and internal, historical and contemporary, diffused and concentrated.

First, there is the historical factor which is rooted in colonialism, trade and imperialism, the routes through which the African continent got integrated into the world capitalist system, which, according to some scholars (Onimode, 1983; Rodney, 1972) has been the main source of impediment to Africa's development and capacity to develop in all spheres, including technology. An interesting and quite detailed analysis of how colonialism and imperialism kept Africa underdeveloped (in technology) has been given by Rodney (1972). It is nevertheless necessary, at least in a general way, to indicate how this integration forged and maintained technological dependence in Africa.

To make our analysis or contentions more meaningful, it may be necessary to give some further

[3] It may not be completely correct to characterize technological dependence in the LDCs this way in view of the phenomenon of 'brain drain', which we shall discuss later.

[4] This hypothesis contends that technological dependence or general underdevelopment in Africa is a natural phenomenon, a condition in which African countries started and have since existed.

evidence on the state of indigenous technology in precolonial Africa. Before colonialism, Africans designed and operated their own small-craft techniques in forms that were bound up with social production such as cloth-making, iron-smelting, blacksmithing, tanning, pottery, mining of minerals, etc. All forms of production were based on local resources. For example, blacksmiths in various parts of Africa produced cutlasses, hoes, knives, guns, spearheads, swords, etc. from locally smelted iron for both productive and military purposes. The African leather industry produced saddles, slippers and handbags from animal skins. African beer and wine (e.g. palmwine, Ogogoro, burukutu, etc.) were brewed from such local resources as palm trees, kolanuts, etc. All the stages of the cloth manufacturing process, including ginning, carding, spinning, dyeing, weaving and cutting, were performed in different parts of Africa, notably in Nigeria where weaving with handlooms still persists. In the area of transportation technology, boats carved out of wood were used for water transport on the various African rivers.

An important implication of the foregoing therefore is that Africa possessed a rich and diversified technological base which, in a way, could be considered adequate for the technological requirements of precolonial Africa; and on which a technological revolution and successful industrial development might have been built but for the historical disaster of the technologically castrating and socially debilitating effects of colonialism and capitalism (Onimode, 1983, p. 17). These effects were transmitted through the functioning of the colonial system and the capitalist mode of production in at least two ways.

First, colonialism, as a fundamental process of elimination (*Ibid.*, p. 82), systematically dislodged and destroyed African countries as far as technology culture was concerned. Indigenous production based on local technology was displaced through competitive forces and pre-emptive tactics. The objective was to ensure in Africa a pattern of development fashioned on metropolitan needs: to make the continent a production base for the raw material requirements of the metropolitan factories and a market base for the products turned out from such factories.

Another way the colonial system worked to fetter or retard technological development in Africa was in terms of deliberate policies not to promote scientific and technical education relevant to technological development in the continent. The colonial system had for long been aware of the importance of scientific and technical education and research in the development of technology but it did very little to orient Africans, in their educational system and development, in this direction. It simply did not create adequate facilities and a conducive atmosphere for the acquisition of technical and technological knowledge in Africa.

For example, science and technical education were not encouraged in African schools, a colonial heritage that still persists in some African countries. At the time of political independence, many African countries could not boast of any technical institutions of learning or of integrated pure and applied science programmes in the schools' curricula; where such facilities existed, they were either too few or marginally relevant. As an example, with a population of 35 million, Nigeria had only one University College (a satellite campus of the University of London) and four technical institutions with a student population of a few hundred at the time of political independence in 1960. Clearly, even a miracle could not predicate any technological foundation on such an ephemeral basis.

We cannot, therefore, isolate the technological dependence of the African economy today from the low level of development of its human resources, particularly when viewed from the contemporary and the above historical perspectives. Generally, Africa has a low endowment of skilled manpower. According to ECA sources (1984), out of 260 million men and women on whom the continent relies for the production of goods and services, some 158 million are completely illiterate. And of the entire African population of 450 million persons in 1984, not more than 13 million had pursued their education beyond secondary school. A minute percentage, a little over 3 million persons only throughout the continent, had benefitted from third-level education; and amongst this, not more than 1 million held a university degree and only 200 000 had received a postgraduate education. And all this was despite the tremendous increase in post-colonial educational enrolments in the continent. Between 1960 and 1984, general educational enrolment increased by more than 280% and by more than 234% for first level and 723% for third level (ECA, 1984, p. 5).

In particular, Africa suffers from acute shortages of critical skills such as engineers, scientists, researchers, entrepreneurs and other human resources (especially those closely related to the process of production) required in technological development. Tables 1 and 2 show the decidedly low endowment of

TABLE 2. R&D scientists, engineers and technicians per million inhabitants in different regions of the world*

	R&D scientists and engineers		
Region	1980	1985	1990
Africa†	84	72	74
Latin America	242	312	364
Asia†	304	336	396
Arab States	330	336	363
Oceania	1774	1414	1610
Europe	1859	1927	2206
North America	2734	3024	3359
World total	894	920	1000

*Source: J.K. Thisen (1993), Table 2, p. 19.
†Excluding the Arab States.

TABLE 1. Technological dependence: selected socio-economic indicators, 1970*

Indicator (science and technology)	Developed economy countries	Developing regions: Africa	Asia	Latin America
(i) Ratio of total stock of scientists and engineers per 10 000 population	112	5.8	22.0	69
(ii) Ratio of technicians per 10 000 population	142.3	8.3	23.4	72.2
(iii) Scientists and engineers engaged in R&D per 10 000 population	10.4	0.35	1.6	1.15
(iv) Technicians engaged in R&D per 10 000 population	8.2	0.4	0.6	1.4
(v) Expenditure on R&D as percentage of GDP	1.2	0.6	0.3	0.2

*Source: Frances Stewart (1977), *Technology and Underdevelopment*, Macmillan Press, London.

Africa in terms of these human resource skills when compared with the DCs and other developing regions of the world.

Thus, in 1970, according to Table 1, there was an average of only six engineers and scientists per 10 000 population for the African countries for which data were available, compared with figures of 22 for Asia and 69 for Latin America. This also contrasts with a figure of 112 per 10 000 population in the advanced market economies. In fact, the poor performance of Africa repeats itself for every socio-economic indicator that could be shown; among the developing regions, Africa consistently fares the worst and Latin America generally the best, with Asia in between. More recent information, as contained in Table 2, shows that no differences have occurred in this regional ranking with respect to the selected socio-economic indicators.

According to the UNESCO data in Table 2, the average figure for scientists and engineers engaged in R&D per million of population in the African region was 84 in 1980 as against 304 in Asia and 242 in Latin America, 1859 in Europe (excluding the former USSR) and 2734 in North America. Worse still, while the developed and other developing regions had a steady increase in their number of R&D scientists and engineers between 1980 and 1990, the African stock of these skills declined during this period.

The African situation is compounded by three related issues. First, it appears that the educational preconditions for technology development in Africa have been underestimated. At present, the total number of third-level institutions of learning (i.e. universities) in Africa is less than 100, only six of which are institutes of technology; 38 of these institutions are in Nigeria, 13 in Cameroon, eight in Egypt, one in most countries and none in some others. Moreover, to a great extent, the existing educational system is still a carry-over from colonial days when the emphasis was laid on the humanities. For instance, it has been asserted (Kakonen, 1979, p. 6) that, on the average, third-level students in Africa divide according to their scientific disciplines as follows:

Humanities and education	28.1%
Law and social sciences	33.8%
Natural sciences	7.9%
Engineering	9.1%
Medical sciences	11.8%
Agriculture	8.5%
Others	0.8%

This picture appears to be quite unrelated to the technological manpower requirements of the African economy. Of course, this first issue is closely related to the poor funding of science and technology education and the level of R&D activities in Africa. The R&D expenditure as a percentage of the gross national product (GNP) is grossly low, less than 0.2% in 1980 for instance in most African countries (Table 3). This contrasts with what the DCs spend on R&D which, in most cases, is far above 2% of the GNP or even the target of 1% recommended in the continental development blue print: the Lagos Plan of Action (LPA).

The second issue is a paradoxical one; it is that even with the gross quantitative deficiencies in the critical skills required for technological development, the available skills are often underutilized and misused. Occasionally, the preoccupations of some of the skilled persons are such that take their minds and energies away from production. It is common to find people with scientific, engineering and technical skills as full-time religious ministers or doing personnel jobs in white-collar employment or, where resources have provided reasonable liquidity, many in this category have gone into commerce where returns are high and the accumulation of wealth is easier, as in Nigeria during the 1970s and 1980s.

In fact, the present structure and orientation of the modern African economy are such that activities are largely directed away from production. This can have a detrimental effect on Africa's hope for any technological development breakthrough, particularly if the technological development experience in Europe during the Industrial Revolution is anything to learn from. It should be recalled that many crucial landmarks in technological inventions, such as Kay's spinning shuttle, Newcomen & Watt's steam engine, etc., took place when British engineers were grappling with the problems posed by production during the period of the British Industrial Revolution. These British examples illustrate our conception of an

TABLE 3. Classification of countries according to R&D expenditure as percentage of GNP, 1980*

R&D expenditure as % of GNP:				
<0.2%	0.2%–0.49%	0.5%–0.99%	1%–1.9%	>2%
Angola	Algeria	Cameroon	Australia	Bulgaria
Benin	Burkina Fasu	Cote d'Ivoire	Austria	Germany
Botswana	Chad	Egype	Belgium	Hungary
Burundi	Congo	Madagascar	Canada	Israel
Central African Republic	Ghana	Senegal	Denmark	Japan
Ethiopia	Kenya	Togo	Finland	Switzerland
Gabon	Liberia	Zambia	France	UK
Gambia	Mauritius		Netherlands	USA
Lesotho	Morocco		Norway	USSR
Libyan Arab Jam	Nigeria		Poland	
Malawi	Sierra Leone		Romania	
Mali	Sudan		Sweden	
Mauritania	Swaziland			
Mozambique	Tanzania			
Niger	Tunisia			
Rwanda				
Seychelles				
Somalia				
Uganda				
Zaire				

*Source: J.K. Thisen (1993), Annex 2A, p. 34.

engineer as a problem-solver, as someone who is engaged in tasks that are 'predominantly intellectual' and 'varied' and not of a routine mental or physical character.

Of course, some scholars (ECA, 1984; Fabayo *et al.*, 1995) are of the view that the (growing) attraction of commerce and public sector white-collar jobs to African scientists and engineers may not be unconnected with the poor quality of their training. This may not be totally incorrect because the technological environment (home and school) in which most African science and engineering students are nurtured in the continent cannot be considered rich enough as it has very little by way of technical clutter for intellectual stimulation, particularly when viewed against what obtains in the DCs. Science subjects which are meant ideally to provide the experience of reasoning, deduction, trouble-shooting, testing and experimenting, all of which seem akin to technological development activity, are taught in many African schools in such a way that these objectives can only be marginally realized.

In some cases, because of lack of funds, equipment, materials and sufficiently talented teachers, the teaching and learning of science subjects is without practical components. In fact, owing to these reasons, the trend in some African countries is towards a depracticalized science or blackboard science, according to Kenneth King (1984, p. 46), in which the emphasis of teaching and learning is on theory. Even where the teaching and learning of science have practical components, these are organized primarily to verify experiments and theories from the DCs. In which case, such a training and learning process does not adequately equip or prepare students for problem solving in the more challenging or tasking area of production in the society.

The third issue relates to the problem of brain drain, involving the outflow of much needed technological manpower. Many qualified African scientists and engineers and experts of all categories are known to have emigrated to the industrialized countries in search for 'greener pastures'. In 1970 alone, 1200 scientists emigrated from Africa to the USA (Kakonen, 1979, p. 7). By 1974, Africa had already lost, to the UK and USA alone, some 13 500 scientists, engineers, teachers, physicians and surgeons (ECA, 1984, p. 6). Today, there are hundreds of thousands of these and other highly qualified Africans operating in the economies of the industrialized world.

While the phenomenon of brain drain may benefit the DCs because it is cheaper for them, it definitely accentuates the problem of lack of internal technological capacity which fosters technological dependence and inhibits development prospects in Africa. The problem is aggravated in a double manner: first, in terms of the number of skilled persons emigrating; and second, in terms of the fact that, most often, those emigrating constitute the best, in terms of quality, among the stock available.

The stock of knowledge about local scientific and technological needs is also limited and biased in favour of imitative socio-economic development. This occurs due to the excessive prestige of imported knowledge, fear of risk in local projects or mistrust in the capacity of local scientists and engineers because of the factor of poor training alluded to earlier. This is a reason for the underutilization phenomenon also mentioned earlier. When local skills are not supported or allowed to undertake technological activities, their chances of development or growth through learning-by-doing are undermined, as are the opportunities for local technological development. The net effect is continued technological dependence, as typified by the experience of Julius Berger Nigeria Limited where indigenous engineers are made to handle only routine office work and irrelevant jobs that have nothing to do with engineering. When six of the twelve Nigerian engineers with the company resigned because of frustration in 1977, the company increased the stock of its German engineers by two (Fabayo *et al.*, 1995).

There are situations in which the basic knowledge underlying a particular production process is indigenous to Africa but, due to lack of local institutional facilities and capabilities for engineering designs, fabrication of machines and equipment, large-scale commercialization and so on, such ideas remain shelved with their originators; meanwhile, Africans may continue to depend on similar ideas developed elsewhere. Sometimes, scholars from the DCs gain access to such stock of local knowledge through seminars, conferences, pilferage etc., perfect it and recycle it back to Africa in the form of import (software and hardware technology). A typical example is the Poundo-yam technology whose idea was initiated by Professor Makanjola of the Obafemi Awolowo University in Nigeria but which was perfected and embodied in machines by the Japanese. Poundo-yam machines, imported from Japan, are used by many Nigerian elites today, including, perhaps, Makanjuola himself.

Another root of Africa's technological dependence can be traced to the nature of Africans themselves, their attitudes, illusions, policies and general admiration or high taste for what is foreign. This has given rise to the creation of a domestic environment and factors that sustain general technological dependence as reflected, until very recently, in widespread failure on the part of many African countries to consider technology within the wider context of alternative policies. Some of the 'factors' we have in mind are: the absence of a coherent technology policy; the lack of rigour in scientific research; the limited application of research results to basic needs; the development of vested interests in the production of western-styled products using western-styled technology; lack of pressure on or inducement for local enterprises to use local resources rather than foreign. This last point deserves some emphasis because in the absence of pressure and special inducements to the contrary, the entrepreneur is likely to opt for the proven performance of foreign technology (UNCTAD, 1977, p. 41).

The dependence on external forces for the local industry's dynamic with respect to product innovation and model changes is a very powerful force for maintaining technological dependence intact. But this is not peculiar to Africa alone. Model changes at the foreign manufacturer's behest make local sourcing and the ultimate development of a design capability very difficult. In other words, the constant model changes, together with the sophistication of some of the required technology, deter its domestic replication. Hence import substitution is extremely incomplete and dependence is prolonged (*Ibid.*, p. 41). For example, there seems to be no way in which African countries can easily catch-up in the world of automobile, electronic and computer technologies, judging from the rapidity with which innovation and model changes occur in these industries. However, the objective is not so much to bridge the technological gap between the DCs and Africa but for Africa to acquire a domestic technological capability that will foster development, reduce dependence and all its associated adverse effects.

4. CONSEQUENCES OF TECHNOLOGICAL DEPENDENCE

A situation of technological dependence has several effects, favourable and unfavourable. While most of the favourable effects are conferred in cases of mutual dependence, the unfavourable effects are conferred in situations of asymmetric dependence.

A favourable effect of technological dependence in Africa is that it permits, through the process of technology transfer, the African economy to benefit from some of the manifold developments of science and technology in the advanced countries without the Africans themselves going through the difficult and costly processes of developing them, particularly in situations when the local resource base cannot, on its own, stimulate, support and sustain what it takes to develop such technologies. Various examples abound in industrial or manufacturing processes (e.g. iron and steel), transport (automobile, aeroplane), telecommunication (telephone), and so on.

Following Stewart (1977), we shall look at the unfavourable effects of Africa's technological dependence from four interrelated perspectives: (i) underdevelopment of indigenous scientific and innovative capacity; (ii) technological dysfunctionality and promotion of distorted development; (iii) loss of control over decisions; and (iv) cost of technology acquisition.

4.1. Underdevelopment of indigenous scientific and innovative capacity

Technology dependence seriously undermines the attempts that might be made by the African countries to strengthen their own capacity for scientific research and technological development. It does so in two ways: it inhibits the process of 'learning-by-doing' which is essential for the development of scientific capacities, and it tends to debase the activities of local scientific and technology institutions, making them either irrelevant or poor copies of those in the industrialized countries.

According to Stewart (1977), and I concur with her, many of the skills that are needed in economic activities, particularly those related to production, construction, etc., are best acquired through the process of learning-by-doing; a process by which the execution of production tasks in one period generates a flow of information and understanding which allows execution to be improved upon in a subsequent period or, by opening the 'black box' of a particular production technology and manipulating its content, generates additional knowledge and understanding. This is because one probably learns little from facing problems (and even much less from ignoring them), but a great deal from solving them.

Although a non-African example, the experience of the Acindar Steel Company (ASC) in Argentina in the 1940s can be used to illustrate how doing-based learning can be an important mechanism for augmenting local technological capacity. With access to imported technology being blocked during the early 1940s, ASC had to draw entirely on local technological resources for designing and building its first small plant at Rosario. When it came to expanding the plant in 1947,

> *Acindar was able to draw on its previous experience in the design, construction and operation of the original furnace so as to introduce several improvements . . . the learning efforts that went on during the initial plant investment helped lower the costs of and improve the efficiency of the subsequent plant expansion.*
>
> *Yet there was a still more important later benefit to Acindar from its early learning in Rosario—an intangible benefit. This was the psychological boost to all the firm's personnel which resulted from the great success with which they brought the plant into being . . . one still senses the confidence and pride of those involved in this project (and) a definite technological optimism both as regards the development of 'home-grown' adaptations and improvements when required and also as regards advancing into technological fields completely new to the company* (Bell, 1984, p. 193).

In Africa, this process of learning-by-doing is blocked, first, by the turn-key forms most technologies imported into the continent take; secondly, by 'lock-in' arrangements that prevent local pressure on foreign firms operating in Africa to use local skills rather than foreign; and thirdly, by the strong preference patterns of Africans for imported things, even when locally made choices are available. Moreover, Africa does not have such rigid controls, akin to those in Argentina, against the outside world.

Discrimination against the use of local skills and resources is a common experience in African countries. Cases illustrating this experience occur in various situations such as: when foreign engineers and technicians are imported to service and repair faulty factory equipment and machines, even when local ones who can competently perform are available; when local businessmen refuse to use local technologies (of proven performance) because of easy and cheap access to foreign ones; when local engineering firms are discriminated against in the award of contracts, etc. Sometimes, African engineers employed by foreign firms are deployed to units where they handle personnel and other such routine matters that have no direct bearing on their skills.

When the foregoing happen and the stock of local skills and knowledge is not encouraged or actively deployed to spheres that are directly relevant, the consequences are clear. The chance of building up self-confidence in problem-solving or the opportunity for a virtually automatic and costless acquisition of increased skill and knowledge is lost, as are the potential benefits from such chance or acquisition. The logic is quite simple: learning-by-doing in technology is impossible without the opportunity of doing (Bell, 1984).

4.2. Technological dysfunctionality and promotion of distorted development

Perhaps the most obvious feature of technological dependence in Africa is the inappropriateness of most imported technology and the frustrating effect of this on the continent's attempt to achieve structural transformation or to its factor proportions or in meeting basic human needs.

Most of the technologies imported into Africa are usually designed and developed for use in the DCs, the base of their production. Consequently, their characteristics are designed to fit in with the economic, institutional and technical circumstances of the DCs. In other words, each technology has its base country; it is determined by the material and social conditions pertaining to that base country; it thrives best under such conditions (Kuaya, 1977, p. 51) and it cannot therefore be a neutral factor in social and economic development.

The implication of the preceding point is that technologies imported into Africa cannot produce satisfactory results if used unmodified because they will be inappropriate, particularly with respect to the local factor endowments and the satisfaction of basic human needs.

Take the issue of factor proportions for example. The scarcity of labour in the DCs has been the major attraction for these countries' development and adoption of capital-intensive techniques of production.

Many studies (e.g. Fabayo, 1987; Olaloye, 1976) have shown that the adoption of the capital-intensive mode of production has aggravated the unemployment problems and social unrest in labour-surplus Africa.

Moreover, notable climatic and ecological differences between the DCs of Europe, North America and Japan and Africa affect agricultural production and processing, manufacturing and construction technologies imported by Africans from the DCs. In all respects, technology designed in the DCs reflects the climatic conditions and resource availabilities in those countries, with the consequences of distorted development, increased cost and/or decreased efficiency when it is transferred to developing regions like Africa.

Let us look at the example of wheat bread. Bread technology has focused on wheat as raw material and not on such tropical or African grains as sorghum, millet etc. because it is wheat that is readily available in the DCs. Wheat bread (based on imported wheat flour, machines and production formula) is a popular food in Africa today. Numerous other examples of imports (raw materials and components) can be cited in such other sectors as energy, transportation etc. In most industries, particularly the major ones such as petrochemicals, iron and steel, beer etc., the import-intensity of the technology in use is quite high. It has been observed in Nigeria, for example, that for every ₦1 worth of manufactured product, about ₦0.68 has gone into paying for imported raw materials (Fabayo *et al.*, 1995). The effect is that, in general, the use of unmodified imported technology in Africa has not only led to inadequate utilization of domestic resources, including environmental resources, it has also provided minimum linkages among the various sectors (e.g. agriculture and manufacturing).

Also, dependence on unmodified imported production technologies automatically means that locally produced commodities will be of foreign design and specification. This will in turn induce cultural and economic conformity to foreign consumption patterns, especially among the elite group who, invariably, are the most favoured by the unequal income distribution that accompanies the use of imported technology within the particular framework of Africa's import-substitution industrialization strategy.

This is why it is, perhaps, not surprising to find African manufacturing industries producing snow-shoes, garments manufactured from pure synthetics such as polyester double-knits or a polyester-wool combination in a hot tropical climate, toothpaste, lipstick, wine and whisky, beer and stout (European liquor), etc., for local or African consumption. It is a common sight to see Africans wearing thick dresses, Dacron shirts, three-piece suits, drinking hot tea and black coffee even in extremely hot weather. Labour-intensive methods of production are most often excluded in the manufacture of these products, some of which are unnecessary, undesired or too costly to meet the basic needs of nutrition, health, clothing and shelter.

The preceding discussion can be extended to the displacement or clouding-out effect of imported capital-intensive technology on some indigenous working methods and production. This has been shown to occur by Fabayo and Alade (1984) in the case of Nigeria where the indigenous handloom artisan system was displaced by the factory mill system based on imported technology, and by Kakonen (1979, p. 5) in the case of Kenya during the 1960s and 1970s when an international soap factory ruined the Kenyan national soap firm. In the same way, imported beer-brewing technology has rendered local palmwine tapping methods almost moribund in the continent. Beer drinking has also not only become popular in Africa, it has displaced indigenous liquor (e.g. ogogoro, peto, palmwine, burukutu etc.) in most African countries. There are also compelling examples in Botswana and Tanzania of the destruction of indigenous bases of technology in wood, metal and clay.

4.3. Loss of control over technological decisions

Technological dependence is an aspect of economic dependence, a situation in which national institutions do not have the right, capacity or power to take and implement decisions affecting the national economy and its component units without a *de jure* or *de facto* veto power being held by foreign persons, enterprises or governments (Stewart, 1977, p. 129). In other words, a situation of technological dependence promotes loss of local control in technological decision-making and consequently inhibits the process of launching domestic technological initiatives.

As a traded good, technology is a monopoly product and its producers usually have control devices specifically designed for the preservation of this 'monopoly' character, an important mechanism for the expropriation of monopoly rent and the exploitation of the technologically weak by the strong. They can control the use and spread of the proprietary knowledge underlying the construction of technology artefacts or the use to which the artefacts themselves are put. Either way gives rise to a situation in which important control variables are in the hands of foreigners, no matter the ownership form of imported technology; be it foreign equity investment, using foreign managers or joint ventures with some foreign managers and finance, or local equity investment with restrictive licensing agreements.

The degree of loss of control will vary among these three forms of ownership, being more in foreign equity investments presumably because they are usually subsidiaries of transnational corporations or investments in which most corporate decisions are taken at the headquarters abroad. Licensing agreement has become an important instrument of control in the sale and use of imported technology, and strongly so with local equity investments. Its content is usually of the form that blocks the power of independent decision-making by the local users of imported technology.

For example, it includes restrictive clauses that tie technical assistance to the use of patents or trademarks,[5] tie additional know-how to existing contracts, fix the price of final goods, determine the source of inputs of machinery and material and spare parts, control the volume of sales, restrict exports, restrict if not prevent local R&D activities, require that know-how mentioned in the contract be kept secret while the contract is valid and after the contract expires, require that any controversy or arbitration be settled in the courts of the licensing country, and require that quality control in the contracts lies in the hands of the licensor. Such restrictive clauses are quite common in asymmetric technological transactions between the DCs and LDCs.

Of course, these are part of the ploys used by the DCs through their transnational corporations to exploit the LDCs and to perpetuate their dependence. The implications of the situation have long been drawn home to the African countries, especially within the last four decades when political independence had planted the desire for economic independence almost everywhere on the continent.

Many African countries attempted to solve the problem in the form of nationalization or indigenization of foreign investments, applied as a strategy to effect local control or reduce the degree of dependence on external controls in matters affecting the implementation of development decisions. Nationalization is the takeover of property by a government while indigenization is the process by which a government limits participation in a particular industry entirely or in part to citizens of the country, thus forcing alien owners either to sell to indigenous entrepreneurs or to withdraw from participation in certain economic activities.

Thus, between 1960 and 1976, there were 628 cases of nationalizations and takeovers of foreign-owned enterprises in Africa south of the Sahara, carried out by 26 African countries (Antola, 1979, p. 119). Africa was the most active in nationalization in the LDCs between 1960 and 1976. Its share in the total number of nationalizations in the world was 39% between 1960 and 1974 (Adedeji, 1981, p. 30) and 43% in the LDCs during 1970–76 (Antola, 1979, p. 119).

But, as mentioned earlier, ownership and management of investment alone may not secure much control on technological decisions. African experiences are quite instructive in this regard. In spite of the general wave of nationalization and indigenization that swept through the African continent between 1960 and 1976, many African countries are still largely remote-controlled from the DCs in technological matters, in both tangible and intangible ways. This may be due to the fact that technological considerations are often not reflected in most African nationalization or indigenization programmes.

The Tanzanian experience vividly illustrates this African situation. After political independence, Tanzania took a socialist course and embarked on a large-scale nationalization of foreign investments in a bid to construct a socialist mode of production without fully counting the cost technologically. The result is, of course, predictable: it has not changed the technological root and dependence of the country. Tanzania still sources the technology it needs from outside and it has to meet the requirements of technology producers in matters of patents, royalties, technology contracts, etc., without much influence. According to Rweyemamu (1976), "investment decisions were made in Tanzania on the basis of the existence of foreign suppliers willing to suggest and carry out projects ... and contracts and production agreements with foreign enterprises became a part of national development policy". This sort of situation places considerable spheres of control in the hands of foreigners in the matter of production techniques, trouble-shooting services, as well as weakening the bargaining power of local firms or users of imported technology.

4.4. Cost of technology acquisition

The acquisition of foreign technology has its associated costs which, according to UNCTAD (1979), may be categorized as follows:

(a) direct costs which include the direct payments for imported technology such as payments for patent rights, licences, know-how, processes and trademarks, and for management and technical services necessary at all levels, from the preinvestment phase to complete operation of an enterprise;
(b) indirect costs which take the form of distorted transfer pricing: overpricing of inputs and intermediate resources which are often reserved by contract to the sellers of technology, and underpricing of the output of imported technology in the external market, profits on the capitalization of know-how, etc.;
(c) miscellaneous or hidden costs which relate to restrictions (e.g. on sources of inputs, access to market outlets, etc.) imposed on agreements for technology imports, transfer of wrong or unsuitable technologies, long-term effects of imported technology that undermine the development of endogenous capabilities. In fact, all the unfavourable effects of technology dependence constitute a cost to the technologically dependent economy.

It is usually quite difficult to calculate adequately the total cost of technology imports on the basis of

[5] Patents naturally provide protection for a certain product while trademarks are aimed at differentiating products and thus creating and maintaining demand for the brands.

the above categorization. Usually, most of the information and calculations that are available in many countries and regions in this respect are based on direct costs. For example, the UNIDO estimates for technology acquisition by the LDCs, which were $1 billion in 1975 and $6 billion in 1985, were based on fees, royalties and other payments for technical know-how and specialized services. Similarly, UNCTAD's 1968 cost estimates of $1500 million for technology imports by the LDCs were derived from payments for patents, licences, know-how, trademarks, management and technical fees.

Africa is not only a blind spot when it comes to information on costs of technology acquisition; quite often, what is available is fragmentary, rarely accessible and of general coverage. Nevertheless, there are general and specific reasons to believe that the burden of technology imports, especially in terms of costs on Africa, must be enormous.

First, Africa is in a weak bargaining position in matters pertaining to trade in technology. It is technologically weak; it does not therefore have the resources, or what it takes in terms of local technical capacity or knowledge, to competently evaluate technology, shop around intelligently in situations of existing alternative technologies and sources, or to strike better deals with the sellers of technology in respect of price, quality, functionality and conditions of transfer of imported technology.

The situation is compounded because the market for technology, like so many others of importance to Africa or the LDCs in general, is imperfect. As such, technology (whether in the form of pure knowledge or embodied in foreign investment and machinery) is transferred under terms that are the outcome of negotiations between buyers and sellers in situations approximating monopoly or oligopoly. This is why bargaining power is very crucial in determining terms of transfer. The final returns and their distribution largely depend upon the relative strength of the bargainers, and an unfavourable outcome is more probable for the weak (UNIDO, 1985, p. 5), the LDCs, since great monopoly advantages (in terms of tie-in clauses in technology sale contracts) exist for the seller which make it possible to sell technology at a price far in excess of its marginal cost. It is really a situation when, unlike the seller, the buyer has little or nothing to withhold which the seller wants.

This exploitative situation is quite unlikely in a perfectly competitive technology market since competition will reduce to marginal the cost of acquiring technology because, once the technology has been developed, its marginal cost is considerably reduced, sometimes nearing zero.

Second, the average degree of patent exploitation is low in Africa. This is because patents granted to foreigners are seldom exploited.

We shall now take two African countries: Ethiopia and Nigeria, on which some scanty information is available to illustrate the African experience with the cost implications of technology in the continent. As said earlier, a frequent precondition for the sale of modern technology is the adoption of tie-in or restrictive clauses in purchase contracts. These clauses tie the inputs to the producer of technology, among others—a precondition which facilitates the application of distorted transfer pricing.

A case study on Ethiopia by Farugi and O'Brien (1976) gives evidence of the significance of these restrictions in Africa. In their sample of 17 Ethiopian firms which carry out considerable intermediate imports, at least 80% received most of their imports through an overseas intracorporate network. This makes it possible to overprice imports and underprice exports by more than 50%. In 1970 alone, the amount of overpricing of intermediate and machinery imports was estimated as 66 million Ethiopian dollars. Considerable undervaluation of exports took place in the firms as well. It was 56% in one firm and as low as 15% in another (*Ibid.*).

In Nigeria, payments for foreign patents, licences and trademarks increased substantially from the early 1960s to the mid-1970s, when the tempo of nationalism culminated in the implementation of strong indigenization and nationalization policies. For example, they increased by as much as 55.6% from $15.4 million in 1963 to $33.8 million in 1965. The 1965 figure was 4.5% of Nigeria's export earnings and 0.72% of the GDP that year (Kakonen, 1979, p. 84).

5. SUMMARY AND POLICY DERIVATIVES

We have, in this paper, attempted to analyse the issue of technological dependence within the context of African political economy. In so doing, we have highlighted the nature, causes and consequences of technological dependence in the continent.

Some of the identified causes of technological dependence in Africa are: colonial interaction and the subsequent integration of the African economy into the world's capitalist system, which made it possible for the technological advancement of Africa to be overshadowed, retarded or even halted by systematically diffused technology from the DCs; the paucity in the stock and quality of S&T resources required for technological development and the emigration, underutilization and misuse of some of the available ones; entrenched taste for what is imported in preference to what is local; and the deliberate efforts on the part of the DCs, through the use of competitive and pre-emptive tactics by their transnational corporations, to perpetuate dependence in the LDCs.

We have also shown that Africa's asymmetric technological dependence is detrimental to its development process and prospects in a rather cumulative manner. It has led to foreign investment at high financial cost, loss of control, introduction of alien patterns of production and consumption, and it has inhibited local technological development efforts in the continent. The combined effects of these adverse effects of technological dependence have, in some ways and forms, contributed to the distorted development or underdevelopment of the African economy.

We therefore believe that unless ATD is considerably reduced, since it cannot be eliminated given the existing internal rigidities, limitations and fragmentation of the African economy and the way the international economic system operates, any hope for a rapid and internally stimulated development of the African economy will remain as a mere illusion.

The policy implications of this study are therefore obvious. They centre, on the one hand, on the need to control and reduce the extent of technology imports so that at least the unfavourable consequences of technological dependence are reduced and, on the other hand, on the need to build up a local technological development capability that can guarantee some degree of self-reliance in technological matters. This implies the effective integration of two main streams: the 'flow stream' with its emphasis on control, selection and acquisition of technology imports and possibly its subsequent adaptation, absorption and diffusion in such a way that the consequences of technological dependence are reduced; and the 'stock stream' with its emphasis on the development of endogenous technological strengths and the promotion of the capacity to innovate in such a way that technological self-reliance is enhanced.

It should be the objective of technological development policy to harmonize both flows and stocks. But attempts at harmonization will need to recognize that the two streams are not independent or mutually exclusive but rather interactive at different levels. It may also be necessary to tackle the problems associated with each stream within different time-frames. The development of capacity to control foreign technology inflow might be afforded short-term importance. Without such a capacity, policies aimed at fostering endogenous technology development and the capacity to innovate are likely to be continuously undermined.

There should therefore be a controlled policy towards technology imports in Africa. This does not mean cutting the flow of foreign technology, but rather regulating it. The African continent should not be a junkyard for all types of technology imports, relevant or irrelevant. The lessons in the experiences of Japan and Russia are of particular relevance in this regard. During the early phase of their development, both countries imported technology but such technology imports were controlled and selective; they were restricted to particular areas of greatest need where they would not inhibit local development efforts, and they were rarely used without local modification. This way, Japan and Russia were able to use imported technology as the springboard for their own very substantial achievements in technological development. These experiences of the two countries were recorded in this century. The history of the United States of America during the early stage of its development in the 18th Century shows a similar pattern.

Some African countries (e.g. Egypt, Cameroon, Nigeria, Libya) should be able to set up similar control structures that will allow for selective technology imports, negotiate toughly on their terms and strive for their adaptive use. This may be quite ambitious because of the prevailing low level of development in African countries, the paucity in the stock and quality of the technological personnel needed to effectively carry out such a programme, and because of African countries' loose controls against the outside world arising from their integrated ties with DCs. However, if such a programme is not contemplated and never started or delayed for too long, African countries may not be able to break the cord of their technological dependence on the rest of the world. The developmental gains from nationalization, indigenization, Africanization and structural adjustment programmes in many countries in the continent should inform the need for this policy suggestion, no matter the nature of the problems anticipated. For example, before the structural adjustment programme (SAP) in Nigeria, not many people were aware of the considerable potentials which existed for local sourcing of raw materials in particular. But today, SAP has altered the raw material mix of some industrial production processes in Nigeria by ensuring greater use of local raw materials, which is a good start for the type of technological adaptation that is being suggested.

Human resource development through education is a particularly important factor in the development of an endogenous scientific and technological development capability needed to dismantle technological dependence. This calls for the strengthening, expansion and reorientation of the education and training systems in the continent so that they respond more directly and effectively to Africa's dire need for the supply of productive skills in general and scientists, technologists, technicians, engineers etc. in particular.

As rightly noted by Fabayo *et al.* (1995), education, especially of the right type and quality, is a basic element of the scientific and technological infrastructure of a country. As such, technology and education plans should be closely interlinked.

Therefore, to rectify the observed problem of paucity, quality and relevance of the stock of S&T manpower in Africa, the African countries must take adequate measures to develop facilities for the education, production and absorption of high-quality manpower. Such measures may include: allocation of adequate financial resources to the institutions of learning, especially the third-level category; improvement of laboratories; greater incentives for science teachers; education reforms that are geared towards providing relevant skills needed to realize technological objectives. These would include reforms such as the introduction of vocational and technical contents in the school educational curricula, especially at the pre-university levels; upgrading and updating of the science curricula; a closer link of this curriculum with the local environment. At the university levels, technical courses should be reoriented so that the awareness of the students of the technological problems in the continent is enhanced.

The 'brain drain' problem in Africa should be tackled with urgent concern. Since relatively unfavourable working and living conditions are the basic causes of migration, African countries should try to improve these conditions and provide incentives to discourage the depletion of the continent's stock of scientific manpower through emigration. In this regard, scientific skills should be deployed to relevant employment areas, provided with adequate tools with which to work and adequately renumerated, because these are essential preconditions for job satisfaction. This will also discourage the movement of (experienced) scientists and engineers away from their professional lines into other sectors within the same country.

There is a need to break the ties with foreign tastes, products and companies which technological dependence has built up, starting from the colonial era in Africa. Of course, this sort of break is more difficult to achieve the more integrated the ties and interests that have developed in the system, particularly when the technological capacity to make the break and provide local alternatives is either weak or does not exist. However, the SAPs which took off in some African countries (e.g. Ghana, Nigeria) since the mid-1980s have started to weaken some of these ties and have shown that this policy objective is realizable.

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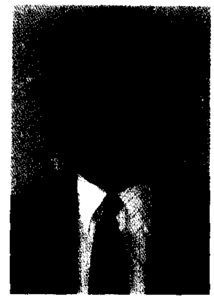

J.A. Fabayo is a Reader in Economics at the Obafemi Awolowo University, Ile-Ife, Nigeria, where he teaches industrial economics, mathematical economics and economic theory. He was educated in that university and at the famous Krannert Graduate School of Management, Purdue University, USA; in the latter, as a Rockefeller Foundation Scholar.

Dr Fabayo is an Associate Editor of *Ife Journal of Economics and Finance* and the author of *Finite Mathematics in the Social Sciences* and *An Introduction to Mathematical Analysis in Economics.* He is Head of Department of Economics at the Obafemi Awolowo University and the Regional Coordinator for Africa of *Survival Development International.*