HISTORY AND THE QUESTION OF TECHNOLOGICAL DEVELOPMENT: THE TRANSFER OF TECHNOLOGY REVISITED

Gloria Thomas-Emeagwali*

Introduction

In this paper we examine some of the conceptual issues related to technology and technology transfer. We observe that at least three distinct meanings of the term 'transfer of technology' are discernible in current discourse on the subject, and that this proliferation of meanings has contributed to ambiguity in discussions. We then focus on the process of transfer of technology in its historical dimension with particular reference to early Modern Europe in the first instance. We argue that the European case is a clear example of successful transfer in the sense that the diffusion of hardware and capital goods, theoretical ideas, skills and personnel from the Middle East, North Africa, China and India, would assist in the development of the technological capability of western Europe in particular. We contrast the early European case with contemporary Third World countries where the process of transfer has been largely unsuccessful vis-a-vis the development of technological capacity. We comment on the local and systemic reasons for this situation.

Connotations of the term technology

Laudan has suggested that the term "technology" has been given such a wide range of definitions that no one scholar can work with all the concepts implied, simultaneously[1]. From the wide range of definitions it is possible, however, to identify some of the major connotations of the term. It is clear, for example, that technology implies an extension of physical and biological capabilities, rational problem-solving and utilitarian activity[2]. Furthermore, it is a product of social interaction and is usually associated with a community of practitioners in the Kuhnian sense[3]. It is, however, not necessarily cumulative and there are several cases of discontinuity in development. Technology may be concerned with the creation of motive power for other tools and is of significance in the development of an economy's capacity to process raw materials and create finished products. In this case, it is a significant aspect of an economy's viability and the nation-building process in general.

There is considerable disagreement with respect to the precise relationship between science and technology. On the one hand technology is seen as "illustrative" of scientific theory and as "applied science", being the application of the fruits of science to practical ends[4]. On the other hand, there is the view that although science and technology are inter- connected, they are independent and distinct forms of knowledge[5]. The suggestion is made that whilst science searches for truth, technology is mainly utilitarian in objective[6]. What is acknowledged by both groups of scholars, however, is that the line of demarcation with respect to the two spheres of knowledge is not only "blurred" but actually indistinguishable as we focus on the more recent technologies such as micro-electronics and bio-technology[7].

The transfer of technology as a concept

Some scholars argue that technology is not transferable, whilst others suggest that it is, and there are cases where the two opposing perspectives are contradictorily embedded in the same work[8]. It may be suggested, however, that the reason for this ambiguity in discussions on the issue relates to the fact that the concept 'transfer of technology' has varied connotations and more than one meaning as used in current literature. It may refer solely to the process of diffusion of capital goods, skills, personnel and techniques. In this case, there is the implication that such a process is both necessary and sufficient for technological development[9]. Another usage of the concept implies that 'the transfer of technology' entails the wholesale transfer of technological capability from one economy to another. Here there is the assumption that technological capability is a transportable commodity[10]. We consider the third usage to be more realistic, namely, the view that the diffusion of capital goods and personnel are aids in the development of technological capability which may be necessary but are not sufficient for technological development since there are a wide range of other variables which are crucial in such a process[11]. We can therefore make the theoretical distinction between a successful transfer whereby the process contributes to the development of technological capacity of the recipient economy and one which is unsuccessful and fails to do so. In the discussion which follows we examine the nature of the transfer in the case of early Modern Europe, and examine the reasons for un- successful transfer in the case of most of the contemporary Third World economies.

A comparative analysis of the transfer of technology in Early Modern Europe and contemporary Third World Countries

There are three reasons why we have chosen early Modern Europe as one of the areas of focus. Firstly, this region constitutes one of the most fertile illustrations of extensive importation of skills, theoretical ideas and hardware in a foundation period of Modern Science[12]. Furthermore, the diffusion would contribute to the development of technological capacity for the recipient European economies and is therefore a case of successful transfer. Secondly, the present writer wishes to emphasize the significance of History in understanding contemporary phenomena through comparative analysis, an exercise which may provide valuable insights into the nation-building process. Thirdly, and more peripherally we wish to emphasize the global origins of Modern Science and Technology and so help to dispel the myth that the latter are the product of purely autochtonous growth in the case of Western Europe in particular, a myth which is buttressed in eurocentric writings on the history of science and technology by varied strategies - which range from the seemingly innocuous practice of westernizing the names of outstanding scientists such as Ibn Sina (Avicenna), al-Kindi (Alkindius) and Al-Haytham (Alhazon)[13], to the relegation of precolonial technology of Third World peoples purely to the realm of Aesthetics and Fine Art. The North African and Asian origins of the theories propounded by the Classical Greek scientists are deliberately ignored even when acknowledged by Herodotus and other Greeks themselves[14]. Outstanding scientists such as Claudius Ptolemaeus (Ptolemy) are denied their North African heritage in some of the texts and there is the systematic and conscious bias in the selection of data and even in periodisation vis-à-vis the history of science and technology[15]. Equally effective is the tendency to Europeanize significant scientific and technological processes even when they evolve from non-European sources[16]. The end result is that Modern science and technology are "alienated from the historical processes and initiative of non-European peoples"[17]. What is worse, as pointed out by Gilliam, technological backwardness is associated with physical type and so that which is not propounded is a thesis of "immutable retardation", a perspective which has its negative psychological implications for Third World peoples[18], denying them of their historic role in technological development.

In this section we focus on the process of diffusion of hardware, theoretical ideas, techniques and personnel in the case of early Modern Europe. In the course of discussion, we reflect on the local and systemic reasons why diffusion would assist in the development of technological capability in the European case as compared to the case of contemporary Third World countries where technological dependence and technological neo-colonialism prevail.

It is seldom emphasized that not only are printing, paper, clocks, gunpowder, the stirrup, the stern post rudder, the abacus and the pendulum of non-European origin[19], but so too are early energy-saving devices and techniques such as the wheel, the wheel-barrow, the seed drill plough, the collar harness, the water mill and the windmill[20]. Forbes locates the place of origin of the watermill in the mountainous regions of the Middle East from where it spread to the West, whilst the Windmill is seen to be clearly of Persian origin[21]. In the case of the watermill we note a time lag between the initial period of introduction, Roman innovation and a more generalized usage between the 12th and 14th centuries. It would seem that attempts to use gunpowder for generating energy failed and so it remained relevant mainly for military technology[22]. On the realm of navigational technology we note that there is large scale borrowing of devices such as the astrolabe, the lateen sail, the quadrant and the magnetic compass. It is important to note, however, that as pointed out by Parry, 'European seafarers first borrowed and imitated then developed and improved their borrowings...', an observation which seems valid for other areas of borrowing besides navigation[23]. Indeed Singer has suggested that generally the technique of metal-working, glass-cutting, enamelling, pottery-making and textile weaving 'were copied for centuries in the West by craftsman who perceived nothing of such quality at home...'[24].

If the diffusion of hardware and technique in the period in question is from East to West, or more accurately South to North, it is not different in the field of theoretical ideas and this would have direct implications for navigational technology and the making of precision instruments. The Astronomical tables of Al-Khwarizimi were translated into Latin, by Adelard of Bath and later Robert of Chester[25]. Al-Battani's astronomical works would become popularised. One of the latter would be translated from the Arabic into Latin as De motu Stellarum[26]. De aspectibus was a translation of al-Haytham's Kitab al-Manazir, which according to Lindberg would be of direct influence on Keplerin in the 17th century[27].

The translated texts are of significance for diffusion because once translated from the Arabic they very often became textbooks in the newly emerging universities of Europe which it has been suggested, arose in direct response to meet the challenge of Islamic scholarship[28]. It is important to note that the introduction of the Hindu-Arabic numerals was perhaps the most significant innovation in the history of Mathematics and was directly responsible for the displacement of the Graeco-Roman system in calculation[29]. Texts such as the Algorismo vulgaris of John of Hollywood, and the Carmen de algorismo of Alexander de Villa Dei are translations of al-Khwarizimi[30]. In the case of Mechanical Engineering we are not clear as to whether the conical valves, automatically operated cranks and such devices as sketched in the Kitab al- Hiyal of the Banu Musa would be directly influential on scholars such as Leonardo da Vinci. Hill points out that the text was translated by Gerard of Cremona and became known by the title: On the Measurement of Plane and Spherical figures[31].

Manuscripts were collected by scholar-amateurs as well as merchants. Diplomatic missions, religious pilgrimages, and the activities of itinerant students were some of the other agencies of transfer. There are several reasons why the process of diffusion cited would lead to technological development in the European case in contrast to the dismal situation in contemporary Third World countries where there is a deepening of technological dependence simultaneous with the attempts at transfer[32]. We shall examine these in the discussion which follows.

Licences, patents and trademarks are part of the paraphernalia which restrict the contemporary diffusion of techniques and hardware. The use of patents is granted within specified limits. Restrictions abound with respect to farther research, the use of specialists not indicated by the donor and the usage of the technology after the expiration of the contrast[33]. It is this situation which led the U.N. General Assembly, in its 7th Special Session, 1975, to demand the implementation of a code governing the transfer of Technology so as to preclude restrictive trade practices[34]. We note that in the earlier period of focus, however, although nation states attempted to exert some measure of control over the technology developed within their realm such control was relatively limited. There are occasional cases were espionage was resorted to - as in the case of the European monks at Constantinople who smuggled the eggs of the silk worm in a hollow cane - but in general the movement of techniques and material objects seemed to have been less controlled. At any rate, recipients were not constrained by the paraphernalia of restrictions since the latter would be largely a product of the competitive capitalism of 19th century Europe, an era which would inaugurate the commoditisation of technology in the context of intense secrecy and competition.

In the contemporary period recipient economies are invariably saddled with obsolete technology which in some cases is a deliberate strategy to reduce the competitive power of potential competitors, or to dispense with machinery which are no longer economical[35]. The situation is worsened by the fact that in the contemporary period the rate of obsolescence of technology is noticeably high and capital and consumer goods become easily outmoded. So invariably, therefore, what is transmitted is outdated by the time it is received[36]. In the earlier period cited the rate of change was relatively slow. For example, the rotary fan, piston bellows, the wheel barrow and the double harness for horses were transmitted to Europe in the 15th century approximately but were known by the Chinese for at least a thousand years. These devices did not however constitute obsolete technology since they were nowhere superseded[37]

Ndebbio has pointed to the high costs to recipient economies of the process of diffusion[38]. Whereas the process was hardly a commercial transaction in the earlier period of reference, in the contemporary era it is accompanied by systematic and massive outflow of capital which includes the cost of the patents, licenses and trademarks, payments to experts for consultancy services and the overall capital involved in profit remittance by transnational corporations which have become the major agency of transmission, and which by virtue of their oligopolistic behaviour are a major cause of overpricing[39]. Apart from the fact that they tend to contribute to the absence of an organic relationship between science, technology and production in the Third World economies within which they operate, these monopolies facilitate "the rate of exploitation between nations" and perpetuate "technological neo- colonialism"[40]. In the earlier period, an era of nascent commercial capitalism, such monopolies did not exist and there was therefore less of a stranglehold on the economies in question. The monopolistic nature of the modern technology market, which of course is a feature of the stage of development of global capitalism remains therefore one of the major systemic constraints to any successful technological transfer[41] .

In the contemporary period we note that the gains made with respect to the development of skilled manpower and local expertise are invariably lost through the process of "the reverse transfer of technology"[42]. 67 % of the 119.000 emigrants from Third World countries between 1961 and 1975 were scientists, engineers and technicians[43] - the very manpower needed to sustain the attempts at technological development and to provide the necessary technical expertise with respect to design, construction assembly, use and maintenance of technical devices. The point has to be stressed that the last two phases are of utmost significance since as pointed out by Atul Wad technological capability implies maintenance and repair capacity[44]. We contrast this with the early European situation where the more general tendency was for groups of Europeans to travel and study abroad in the East and to return after the extended stay abroad, armed with volumes of manuscripts and samples of foreign technology. A classic case is that of Leornardo of Pisa who travelled to Algeria and other parts of North Africa and who is credited with introducing Hindu-Arabic Arithmetic into Europe, based on the manuscripts of al-Karaji and al-Khwarizimi[45]. In the case of Constantine travel abroad resulted in the assiduous translation of volumes of Medical works of Middle Eastern scholars[46].

Olufoegba has pointed out that there are necessary and sufficient conditions for the successful transfer of technology and that one of these conditions is the "willingness of the receptor nation to establish the body of manpower that has the capabilities to identify, digest and assimilate the techniques of a particular technology[47]. In the European case, we note the systematic and sustained efforts at assimilation and innovation. Early Modern Europe did not attempt to re-discover the wheel[48] neither did the Greeks and Romans of Antiquity who absorbed a wide diversity of Egyptian and Middle Eastern techniques and devices such as the axle, the chisel, the mallet, the pulley and the concept of the arch, the vault and the dome, in terms of building technology[49]. Nor are we aware of their rejection of indigenous techniques and principles which were proven useful[50]. The colonial episode was a disastrous one for most Third World economies as far as the development of technology was concerned, for it was characterized by deliberate strategies of 'de- skilling' and 'de-industrialization' in several cases[51]. In spite of this, however, there are areas where indigenous techniques and devices are available[52]. There must be a well-researched programme for the selective utilization of such techniques <u>simultaneous with</u> the application of newly acquired ones but there are inbuilt difficulties given the local and systemic constraints.

Conclusion

In this paper we have examined the theoretical underpinnings of the concepts 'technology' and 'transfer of technology'. It is argued that a comparative analysis of the process of transfer in early Modern Europe and contemporary Third World countries reveals that there are certain factors inhibiting the successful transfer in the case of the latter - factors which did not prevail in the earlier historical context.

Notes:

* History Department, University of Ilorin, Ilorin, Nigeria.

1. R. Lauden (ed.) The nature of technological knowledge: Are models of Scientific change relevant, Reidel, 1984, p. 3.

2. Laudan, *op.cit.*, pp. 1 - 26.

3. The reference is to Kuhn's community of scientists bound together by a common paradigm during the period of 'normal science'. For 'normal technology' as a concept see Gutting in Laudan, *op.cit.*, pp. 47-66. See also Thomas Kunn, 'The structure of scientific revolutions' University of Chicago Press, 1973.

4. See Derek De Solla Price, 'Notes towards a philosophy of the Science/Technology interaction', in Laudan, *op.cit.* pp. 105-114 for technology as 'applied science' see Gutting's comments in Gutting ;*op.cit.*, p. 62.

5. See De Solla Price in Laudan, *op.cit.*

6. Note Popper's refutation of the perspective that science searches for truth. See K. Popper, 'The Logic of the social sciences' in Adorno et. al. The positivist dispute in German Sociology, Heinemann, 1976.

7. This issue has been discussed elsewhere. See G. Thomas- Emeagwali in 'Perspectives on the development of electronics technology: The implications for dependent capitalist economies in Afrique et Développement, CODESRIA, Senegal vol. XI, no. 1, 1986.

8. In the third category are those who declare that technology is not transferable and then proceed to specify conditions for successful transfer.

9. Modernization theorists tend to fall into this category.

10. Technological capacity cannot be commoditised although it is quite true that technology itself has become a commodity and an object of buying and selling, as Ghana points out in 'On the political determinants of Technological Revolution in Nigeria', mimeo. University of Jos, Plateau State, Nigeria, Nov., 1983.

11. For perceptive analyse, on the necessary and sufficient conditions for technology transfer see B. Olufeagba, 'Industrial and Technological development: A rational perspective', mimeo., University of Ilorin, Ilorin, Kwara State, Nigeria, April 1986; E. Lambo 'Technological development in Nigeria: Going beyond rhetorics, "Paper presented as Public Lecture at the 12th Convocation of Kwara State College of Technology, Ilorin, Nigeria, 4 February, 1987.

12. The line of demarcation between the late Medieval period and what we refer to as Early Modern Europe is often indistinct and artificial with respect to the issue at hand. There are several cases where initial contact with a technique or theoretical system dates back to the 9th or 10th century A.D. and would be fully integrated much later. For example, Al-Haythm's work on Optics of the 10th century would influence Kepler in the 17th century. See David Lindberg 'The science of Optics' in D. Lindberg (ed) Science in the Middle Ages, University of Chicago Press, 1978, pp. 338-368.

13. We note other relevant examples such as Al-Ghazali (Algazel), al-Farabi (Alpharabius), Ibn Rushed (Averroes).

14. For a relevant comment on this issue see also Susantha Goonatilake, Aborted Discovery, Zed Press, 1985.

15. We note that Ptolemy was also an outstanding commentater on technical devices.

16. We note also the Europeanization of botanical names and phenomena such as "Halley's" comet.

17. See Goonatilake, *op.cit.*

18. Angela Gilliam, 'On the problem of historicist, categories in theories of human development, in Proceedings of the World Archaeological Congress, volume 3, Southampton, 1986.

19. With the exception of the *abacus* and the *pendulum* which are of Middle Eastern origin the devices mentioned are Chinese in origin. See Needham, Science and Civilisation in China, volume one, C.U.P., 1975, pp.240-241. See also Winter, Eastern Science, John Murray, 1952; Singer, et alia, A history of technology Hall & William, O.U.P. on the abacus see Pederson, 'Astronomy' in D. Lindberg (ed) Science in the Middle Ages, Chicago Press, 1978, p. 309.

20. See Needham op.cit. and R. Forbes, Study in Ancient technology, vol. II, Leiden, E.J. Brill, Netherlands, 1965

21. Forbes, *op.cit.*, p. 120.

22. See K. Mendelssohn, Science and Western dominance Thames and Hudson, London, 1976.

23. See Parry, Europe and a wider world 1415-1715 Hutchinson, 1969, p. 20.

24. See Singer, *op.cit.*, p. 762.

25. See Pederson, 'Astronomy' *op.cit.*

26. Pederson, *op.cit.*

27. See D. Lindberg, 'Transmission of Greek and Arabic learning to the West' in Lindberg (ed) *op.cit.* See also Lindberg, Theories of vision from Al-Kindi to Kepler, Chicago Press, 1976.

28. This issue has been discussed briefly elsewhere. See gloria Thomas-Emeagwali 'Reflections on the development of science in the Islamic World - and its diffusion into Nigeria before 1903' in Journal of the Pakistan Historical Society, July/October 1987.

29. See Winter, *op.cit.* See Abdullahi, The Muslim contribution to Mathematics, Humanities Press, 1977.

30. See Mahoney 'Mathematics' in D. Lindberg, *op.cit.*, p. 151.

31. See The Books of Ingenious devices by the Banu Musa bin Shakir, translated and annotated by D. Hill, Reidel, 1979.

32. See for example Atul Wad, Science, technology and industrialization in Africa, Science and Public Policy vol 12.4.85 See also Fidel Castro, Nothing can stop the course of history, being an interview granted to Jeffrey Elliot and Mervyn Dymally, Editora politica, La Habana Cuba 1986, p. 147.

33. See N. Volkov and R. Zimenkov, Technological neo- colonialism, Progress Publisher, Moscow, 1986, p. 58.

34. Volkov, *op.cit.*, p. 80.

35. See B. Ekuerhare, 'On industrial underdevelopment in Nigeria', mimeo. A.B.U., Zaria, June, 1982.

36. This is particularly so for electronics technology for example. See relevant comments in G. Thomas-Emeagwali, 'Perspectives on the development of electronics technology' Afrique

et Développement CODESRIA, vol. XI, 1986.

37. See Needham, *op.cit.*

38. See J. Udo Ndebbio, 'Growth process and economic transformation through technological transfer in Africa' in Science and Public Policy, vol. 12.4.1985.

39. See Ekuerhere, *op.cit.*, See also Ndebbio *op.cit.*

40. See Gana, *op.cit.*. See also Volkov *op.cit.* for the concept of 'technological neo-colonialism'.

41. See Ndebbio, *op.cit.*

42. See Volkov, *op.cit.*, p. 65.

43. See Volkov, *op.cit.*, p. 62.

44. See Atul Wad *op.cit.* See also J. Asalor, "The reliability of vehicle brake lights in Nigeria; A test of the Nation's technology foundation", in B.J. Olufeagba et alia (eds) Technological development and Nigerian industries, vol. one, 1986.

45. See Mohoney, *op.cit.*

46. This is done on the llth century but the impact of Constantine's work would go beyond that period. We should note that "Constantine the African" as he is sometimes called was North African. His translations from Arabic into Latin would have tremendous influence on the development of Médicine and scholarship in general.

47. See Olufeagba, *op.cit.* See also Lambo *op.cit.*

48. This observation is in direct response to the insightful question raised by Owolabi, namely, whether or not we could afford 'to rediscover the wheel' and still hope to achieve desirable objectives 'within the shortest possible times'. See Owolabi, in 'Relevant strategies and modus operandi for achieving desired goals in technology and industrial development in Nigeria' in Olufeagba et alia *op.cit.*, p. 94.

49. See Winter *op.cit.*, Forbes *op.cit.*, Needham, *op.cit.*

50. An interesting example of the retention of an indigenous European technique along with an imported one is seen in terms of navigational technology - the retention of the square rig simultaneous with the adoption of the Arab lateen sail in the 15th century. See Parry, *op.cit.*, p. 23.

51. See Ekuerhare *op.cit.* See also W. Rodney, How Europe underdeveloped Africa, Bogle

L'Ouverture Pub. 1972.

52. E. Uba Nwuba's research into Nigerian traditional agricultural hand tools is a work in this direction. See E. Uba Nwuba, 'Improved hand tools for Green Revolution', mimeo, Agricultural Mechanization Section, College of Agriculture A.B.U., Zaria, September, 1981. The observation is equally valid for areas such as traditional medicine, textile technology etc. See the communique seminar of Scientific re-examination of traditional Health care Held 2nd May, 1987, University of Ilorin, Ilorin, Nigeria.

RESUME

Nous examinons dans cet article certains des problèmes conceptuels liés au transfert de technologie avant de passer à l'étude proprement dite du processus de transfert technologique, dans ses dimensions historiques.

Nous nous référons en particulier à l'Europe au début des temps modernes et nous soutenons que dans le cas de l'Europe le transfert de technologie a été une réussite dans la mesure où les idées théoriques, les techniques et les instruments nécessaires importés du Moyen Orient, de l'Afrique du Nord, de la Chine et de l'Inde allaient poser de solides jalons pour le développement technologique en Europe.

Nous étudions ensuite le cas des économies actuelles du Tiers Monde par rapport à cette situation et nous démontrons que, contrairement à l'Europe le transfert de technologie dans ces régions a échoué lamentablement pour ce qui est du développement des capacités technologiques. Nous explorons les causes locales de cette situation ainsi que les causes procédant des systèmes tout en définissant les conditions indispensables à un transfert couronné de succès.