New Information - Communication Technologies in Scientific Communication: Implications for Third World Users

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"Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?"

T.S. Eliot, "Choruses"
from **The Rock** I.

The Transfer Process - some important historical points

The communication of scientific knowledge to the Third World is important to help ameliorate the worst forms of poverty, enhance economic development, increase the general well-being of the population and bring about greater equity in world affairs. However, the advances of modern technology are taking place very fast. It is most desirable that developing countries have a stake in these advances and make the best use of new information technologies and so participate in the solution to the world's inequities rather than be part of the problem.

The central focus of information technology in developing countries has to be on the many target populations, information to and from the villages, farmers as well as researchers and decision makers. The mode in which benefits are obtained from use of knowledge is important. The question of how best to communicate science and its problems in the third world context is not a new one. This is already the subject of a large body of academic literature. In this paper, I will argue that it is important to consider the historical causes of technology transfer because they have a bearing on the present situation. Historically, I will point out that the developing countries began under a severe handicap giving rise to a growing "technology gap". There are lessons, too, to be learnt from earlier experiences in more technically advanced countries. Apart from some

of the obvious difficulties presented by the introduction of new technologies generally, I will try and provide an overview of the socio-economic and cultural implications inherent in the current "Information Revolution" and their importance for the communication of scientific knowledge. Economic Development is basically a learning activity which is successful when a particular country learns to make best use of existing resources, takes those most appropriate from advanced sources and applies them in a manner best suited to the country's own priorities and aspirations. Empirical studies of structural change in developing economies increasingly are showing changes in allocation of resources towards information systems.[1]

The user of scientific information living in one of the more advanced countries which we often refer to as the industrialized "North" can expect to draw on a vast array of information tools and methods to obtain answers to the questions posed. Libraries and information centres cater to every need. Greater access to information for everyone has largely come about by the rapid introduction of new information technologies. Efficient means of information dissemination and communication in turn facilitates growth in other sectors of the economy. We are all affected directly or indirectly by this so called "information age" we now live in. The computer is now readily accessible to a large part of the population in the "North". Computers have not only acted as more efficient stores of information, but also have become capable of manipulating data they contain in order to create new information. For example, a computer containing data on commodity prices and exchange rates can be programmed to indicate comparative costs in different countries in a single currency. Bibliographic data bases are also widely accessible so that the average user sitting at home, through the computer, can draw on the resources of many of the world's great libraries simply at the touch of a button - and, of course, the payment of the appropriate connection charge! Added to this, there is a range of supplementary choices available to obtain really vital pieces of information: research institutions, specialized information analysis centres,

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[1]OECD, Information activities, Electronics and Telecommunication Technologies, Vol 1 (Paris: OECD, 1981).

and referral centres. At a further level one also can draw on computer clubs and users groups. The number of channels by which one can gain access to this treasure house of sources are also very varied and range from professional societies, literature searches, expert systems, information brokers, as well as the more conventional libraries.

North-South Situation

Access to scientific information in poorer countries, sometimes referred to as the South, is limited in contrast to the situation described in the North. The "South" lacks the necessary infrastructure to support the type of services the "North" has come to expect. The new information technology has been developed in response to the demands of industrial society. At present, we are witnessing a growing gap between the North and the South, i.e., those with access to information, versus those who lack it. This is commonly referred to as the "information gap". It is growing at an exponential rate in much the same way as the "literature explosion". Put the two conditions together and we are presented with a situation that is compounding world poverty just as much as another economic factor in the development process. "Knowledge", claimed Dr. Johnson, "is of two kinds. We either know a subject ourselves, or we know where we can find information upon it." In this sense, knowledge is power - "Nam et ipsa scientia potestas est" as Frances Bacon (1561-1626) postulated - and, if left to its own devices, the current information revolution will reinforce the power dynamics of the current global situation creating a permanent dependency relationship of the South on the North for access to scientific and technical information needed for development. This need not be the case, given some commitment on the part of the North to share in technological developments in the information-communication field in a manner that is more likely to permit more equitable development so that the South will be able to maintain a position in the changing world. The situation is bad, but not all that bad. Later in this paper I will attempt to show some examples which have had encouraging results.

The development problem we then face is complex but may be summarized thus:

- How can we provide greater access to scientific information for people in developing countries; and
- How can new information-communication technologies be effectively transferred to developing countries so that they will not be denied partnership in the information revolution?

The development issues facing poorer countries need to be matched by the creation of sound research and development institutions and capacity building. Information infrastructure is basic to this process. The principle that those who create knowledge have a duty to see that it is disseminated should apply. However, given the fact that socio-economic, cultural, educational, technical and environmental factors are different in each country we need to consider the following basic assumptions:

- that poor countries do not have the resources to build independent and comprehensive information systems, services and networks; any attempt to address needs in this respect will have to be based on co-operation;
- that to escape the dependency relationship on available information services in the North that is being built up, a developing country will need donor assistance in acquiring the information it needs because it cannot, in the long term, rely on foreign sources to make selections on its behalf;
- that unconnected and independent proliferation of information systems and services can result in duplication and overlap; co-operation and collaboration make for economies of scale, reduce waste and optimize use of indigenous resources; and
- adoption of new information technologies to be effective must be appropriate and adaptable to local conditions.

The History of Technology Transfer

Modern economic growth has been attributed in part to the advancement of knowledge and the utilization of the results of new research. Karl

Marx identified technical advances as the reason for changes from one production mode to another. Schumpeter (Theory of Economic Development, 1912) considered technical innovation as the main cause for economic growth and the absence of technical innovation for decline or failure. Specialists in economic analysis have placed great importance on the role of technology transfer in explaining why some economies grow and others do not. However, these theories are somewhat controversial and some social scientists have questioned the role of technical change in progress. Some have argued that it might be possible to describe technological shifts as a function of the market - changes in demand or profitability. It is not generally accepted, however, that such explanations would apply to developing countries where there are wide divergencies, both socio-economic and cultural, which prevent the adoption of generalist theories and which may or may not have matched conditions in more advanced countries.

However, one cannot ignore history and examples taken from the past can provide evidence of general problems, some of which may be avoided in new situations or expediencies to permit faster adoption of practices in countries involved with new technologies. In this respect, I maintain that new information technologies are no different from any other technologies that are being transferred to a country for the first time. Technology has always been transferable from one country to another but there are costs chiefly identified with technical, economic, environmental and political factors pertaining to the country to which the type of new technology is being transferred. Developing countries have, on the whole, been unable to respond rapidly to new technologies because of lack of the necessary infrastructure.

In classical economic terms, many developing countries are caught in what Leibenstein has described as a low level equilibrium trap where technology and infrastructure are at such a primitive state of development that the incremental costs of modernization do not promise sufficient rate of return to encourage further investment in capital equipment. Yet other developing countries, such as China, have been trapped at times in their history by the opposite effect. For

instance, what caused the technical revolution that made twelfth century China the most advanced state in the world at the time? Why did Sung China's flair for new technology disappear so rapidly and why did it fail to capitalize on the results of technology and, thus, spawn the equivalent of the industrial revolution in the West? The answers are complex but may be found in China's ability to keep ahead of its neighbours in basic skills such as farming and military technology and this had a spin-off effect in other sectors of the economy. The reasons for China's technological stagnation after 1350 AD are equally elusive but include the paradoxical "high level equilibrium trap" whereby technology, particularly irrigation and water transport, was so perfected in traditional terms as to place a block on the expansion of per capita demand and thus discourage investment of time and money in new technology. There are analogies elsewhere in the developing world at various times. India might also be a good example of this paradox.[1]

Economic Development must be based on the creation of new structures and a service sector that can provide supportive features to permit new technologies to survive and consolidate. Let me try to clarify this concept by the example of the so-called Newly Industrialized Countries (NICs), a term mainly applied to some countries in Southeast Asia, Korea, Taiwan, Singapore and some Latin American countries, e.g. Brazil.

In the changing economy the information sector in these countries is given new prominence alongside other important sectors of the national economy. This has been described by Porat as the Primary Information Sector.[2] This sector includes goods and services that provide

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[1]For a fuller discussion of this, see, for instance, M. Elvin, The Pattern of China's Past (London: Eyre Methuen, 1973).

[2]M. Porat, The information economy definition and measurement. Office of the Treasurer Special Publication 77-12(1) (Washington, D.C. Dept. of Commerce, 1977).

information or are related to the collection, processing and dissemination of information or are established markets. It includes not only the micro-electronics industry, communications and education but also a wide variety of goods and services. Porat also describes the Secondary Information Sector which includes in-house information activities; for example, information activities by private industry and government institutions which are not transacted on established markets.

In recent times, NIC countries have been able not only to absorb new technologies but also consolidate the experience and build on it, creating whole new industries around the original technologies. A good example of this would be the information sector in Korea which has been found to be expanding faster than any other sector of the economy. For instance, a recent study employing shift-share analysis, initially developed for OECD economies, was applied to the Korean economy over the period 1975-1980. The results revealed that the information sector had the highest rate of employment expansion of any macro sector. Moreover, employment in non-information services was found to increase at less than half the rate that was experienced in the information sector.[1] Other studies support this thesis and have been carried out in several countries in the region.[2]

Countries able to do this have had in place the necessary supportive structures such as education, planning and marketing forces which were able to provide for a skilled workforce, government intervention and entrepreneurial skills.[3] Such economies place a high value on exchange of information and may be called information-based societies. Transfer of technology may be said to be complete when it has been localized and utilized as an integral part of the domestic

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[1]H.J. Engelbrecht, "An information sector perspective of employment in the Republic of Korea, 1975-80" Developing Economies 25, 1 (1987) p. 26.

[2]Ibid, p. 20.

[3]C.J. Dahlman, B, Ross-Larson & L.E. Westphal, "Managing Technological Development; Lessons from the Newly Industrialized Countries" World Development 15, 6 1987 759-75.

economy as import substitution.[1] The role of integration of technology in economic growth is enhanced by the two-way flow of information and the NICs have capitalized on this to the full. The feedback process is involved in all steps of the transfer process, (ideas - invention - awareness - adoption - adapting to local conditions - testing - debugging and acceptance). It is also shaped by the activities of change agents and information brokers capable of giving technical information, means and consultation to industry. The main issue for many developing countries, especially the poorer ones, really lies not in acquiring new information-communication technologies but, rather, it is in acquiring the capability to use existing technologies more efficiently, to use the experience in investment to adapt and improve technology in use. The main path towards the goal will be to build on affordable and viable technologies from abroad while developing local capabilities for repair and maintenance and training programs. Because all capabilities cannot be developed at the same time, the sequence of events in which technical capacities are developed will be crucial. These capabilities change as national priorities also change. Selectivity must be the focus of national information policy, based on feedback from application.[2]

Change comes about in many ways but the successful countries have, at some point, begun to put in place the necessary building blocks in the economy that will support the advances thought desirable. There is a change in the level of industrial and entrepreneurial activity closely linked to technical change. In the case of information technologies, the very earliest examples can be pinpointed to the introduction of printing. The Gutenberg revolution was a major factor in the spread of knowledge.

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[1]See, for instance, J.F. Gaski, "The Cause of the Industrial Revolution. A brief single factor argument", J. of European Economic History 11 (1982), 227-34; and A.P. Usher,"The Emergence of Novelty in Thought and Action", in S. Lieberman (ed.), Europe and the Industrial Revolution (Cambridge, Mass: Schenkman, 1972), p.49ff.

[2]Dahlman op. cit. p. 762

"He who first shortened the labour of copyists by device of movable types was disbanding hired armies, and cashiering most Kings and Senates, and creating a whole new democratic world."

Thomas Carlysle (1795-1881)
Sartor Resartus Bk i Ch 5.

The rate of recording information increased after printing was invented, largely because someone saw the economic benefits of publishing books. Printing created income, profit increased and, hence, it became more and more attractive to more and more people. The concept I wish to emphasize here is one of income generation as an important factor in technological change. We are all familiar with the Industrial Revolution which first took place in Britain followed later by the United States then by other European countries and finally by Japan at the beginning of this century - there being a distinct relationship between the flow of goods and services between countries. This has been referred to by some analysts as the "bandwagon" effect. This effect has also often been accompanied by breakthroughs in energy, transportation and electronics. Countries that were slow to join the bandwagon effect found it harder and harder to do so the further up the road the bandwagon went. In Europe, late developers, typified by countries with a traditional agricultural sector, such as France, Germany, Poland and Russia, Spain, and Portugal, also lacked the supportive structures. Developing countries, hampered by colonialisation, could not get on the bandwagon at all and, it may be said, as a result they were never properly in the race.

The technological gap has since been allowed to grow dangerously wide to the point that it may even be irreversible. For instance, in 1800 British industry had 5 to 6 per cent new

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[1]E.H. Tuma, "Technology Transfer and Economic Development. Lessons from History", J. of Developing Areas 21 (1987), 407.

technologies whilst its colonies had less than 0.5 per cent. By 1830, Britain had rapidly increased its share of new technologies to 32-40 per cent of its total industrial sector, yet the colonies lagged at less than 1 per cent. By 1900, when Britain had achieved nearly 80 per cent new technology, the colonies still had less than 10 per cent. Thus began the dependency relationship, where the developing world became increasingly reliant on the industrialized world for technical solutions to its problems. This dependency relationship has continued to grow. It is particularly applicable to the problem of information sharing and the introduction of new information technologies.

The continual widening of the technology gap and increasing dependency relationship between countries of the "North" and countries of the "South" has been intensified by economic forces and the growing indebtedness of many developing countries. People in developing countries earn low per capita incomes. According to a recent World Bank report, 87 out of 129 countries earn less per capita than one-fifth of the per capita income of industrial countries.[1]

Most developing countries are agricultural economies and have to rely on surplus products from the agricultural sector to provide cash to purchase inputs of foreign technology. Very few poorer countries have agricultural surpluses and are food deficit countries. Foreign exchange simply is not available for capital investment.

This situation is also most acute in African countries where now information technologies are considered by some writers to be a long way ahead of local infrastructural requirements.[2] The lack

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[1] World Development Report. (Washington, D.C.; World Bank, 1988),

[2] A. Ochai "The emerging information society". International Library Review 16, 4 (1984) 367-72.

of income and corresponding low levels of investment stunts growth in Research and Development. The World Bank highlighted this in a recent report[1] which extrapolated the numbers of research staffs available by the year 2000 based on the percentage of Agricultural Domestic Product.

Table 1

Projected number of agricultural research scientists required for national systems to year 2000 - sub-Sahelian Africa.

	Percentage of AG DP to Research	Number of Agric.Scientists
West Africa		
Scenario 1	1.00	14,000
Scenario 2	.67	10,000
Scenario 3	.33	5,000
East Africa		
Scenario 1	1.00	15,500
Scenario 2	.66	11,000
Scenario 3	.28	6,500

Source: World Bank Development Report on Africa

The Table above sets out three scenarios of AGP dedicated to research. Scenario one represents the most opportunistic prediction, but the study suggests many African countries will be hard pressed to meet even the figures in scenario three. Thus, the total number of scientists trained locally for the whole of sub-saharan Africa by the year 2000 will be somewhere between 11,000 to 12,000. (These figures do not include replacements for existing expatriate, core universities or parastatal staff.) This is a grim situation and is further evidence of the continued dependency relationship in the North for key research posts. Information programs are affected by this serious situation and

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[1] World Development Report. (Washington, D.C. World Bank, 1985), p. 10

African countries must pay attention to the resources necessary in planning information systems and services, especially the capacity to define the situation and the problem of information transfer before the adoption of new information technologies.[1]

The existence of a buoyant capital goods market is also an important determinant in the transfer of technology in terms of both absorbtive capacity and motivation to provide upward pressure to continue the pattern and rate of change. According to Rosenberg[2] the creation of an industrial base is a means for institutionalizing internal pressures for the adoption of new technologies. Where this pressure does not exist, transfer rarely takes place. This is well illustrated in developing countries where weak internal forces fail to garner sufficient power locally to muster changes in the technical environment. This is particularly true in the case of the library and documentation situation in developing countries. Some countries like India have strongly developed national information policies and professionals able to some extent to form a strong enough lobby to affect some degree of change.[3] Contrast this with the African situation where lack of trained human resources fails to create the demand and keeps up the pressure for new technologies. The overall picture of the internal constraints on transfer of new information technologies has been summarized by Eres[4] and are adapted in Diagram 3.

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[1]M.B. Stone, "Information Systems and Services to Support the World Community", Canadian Library Journal 42(4) (1985), 204.

[2]N. Rosenberg, Perspectives on Technology, (London: Cambridge University Press 1976) p. 164.

[3]R.P. Kumar and P. Attri, "Development of New Technologies in India and their impact on the dissemination of information". Internationa Library Review. 19,4 (1987) 387-400.

[4]B.K. Eres, "Transfer of Information Technologies to Less Developed Countries. A systems approach", J. American Society for Information Science 32, 3 (1980), p. 99.

General Factors	Conditions in Developing Countries
1. Economic	Labour intensive society Low availability of capital Inability to absorb recurring costs Expense of international activities Lack of internal competition Problems with foreign exchange regulations
2. Manpower	Lack of available trained manpower Low prestige of information professionals Difficulty in recruiting specialists Lack of continuing education
3. Physio-ecological	Limited resources Geographic isolation
4. Cultural, demographic and social	Large percentage of unskilled workers Language barriers Fear of modern technology Inaccurate expectations of technology Information-seeking behaviour of scientists and technicians, especially its low priority.
5 Political	Unstable governments Desire for often excessively tight security and secrecy Constantly changing priorities Centralization of decision makers Lack of scientific impact at highest levels of government
6. Existing information	Poor quality of telephone service Inadequacy of postal service Tight, stringent customs systems Inability to join telecommunications networks Lack of library and information standards Insufficient hard-copy collections Absence of sufficient informal information flow.

Table 2 Factors inhibiting information technology transfer.

The factors suggested by Eres would tend to seriously inhibit the transfer process. Sustainability would be difficult but surely, the problems associated with social, economic, cultural and political constraints are not insuparable. The opportunities presented by new information technologies suggest that it is important to look for adjustments. Nevertheless, even with such constraints there are possibilities for successful transfer of technology and there are many other factors that can be attributed to success or failure, such as the existence of good:

- communication
- co-operation
- management
- planning and control
- participation; and other
- control features

It is possible to measure success or failure in quantitative terms using efficiency standards developed by economists for industry or firm levels of aggregation using linear programming and linear regression techniques. For the information industry, efficiency is a relative term since it should be measuring non-allocative efficiencies. What Leibenstein called 'X' efficiency. Such studies have been carried out on a number of developing countries e.g., Ghana, Tanzania, Thailand, etc. for various industries. It is therefore, misleading to make generalizations about success and failure in the developing country context without adequate analysis in a given situation.

In the broadest sense, however, the problems facing countries of the South today are very serious indeed. Beginning the race under handicap, the backlog of forces have become formidable hurdles to overcome. Current high costs of new technologies are an increasing burden on countries lacking foreign exchange. Many developing countries are conscious of the fact that to introduce technologies and develop their economies investments have to be made in education and advances in general literacy levels. Some

countries such as Ethiopia, in promoting education have run into problems with a rising educated youth now facing employment problems. The local economy cannot absorb the expansion in numbers of educated people. Because of lack of necessary improvements in other relevant sectors, school leavers cannot be gainfully employed in industries able to use their skills. Unlike the NICs described above, the necessary infrastructure is not in place. Ethiopia is a good example where the human skills exist but the corresponding value added in terms of capital goods industries for new technology do not exist. Several problems have plagued Ethiopia, apart from policies in general. With regard to education, the student population has increased more rapidly than state budgets for science and technology facilities. Libraries and information services have fared particularly badly. There is a ready supply of librarians but too few libraries to work in and those available lack the tools to work effectively. It is one thing to train people and another to put trained staff to use. A serious result of this is that those who can leave do. The "brain drain" of educated staff from developing countries to international organizations and to industrial countries is a growing fact. Under this situation, developing countries continue to be consumers of scientific information rather than producers. For instance, between 1963 and 1976, Arab countries established 567 new projects, but virtually in none of them was there any technology transfer in the sense of acquiring the knowledge and skill to maintain and do it themselves independent of expatriates.[1]

It is often said that markets in developing countries are too small for effective transfer of new technology. Demand is too weak. This is very important in terms of information. Since no information service is cheap, high costs will accrue to storing and disseminating information to users in developing countries. New technologies to ease the job will also be very costly. We

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[1]Tuma, op cit., p. 420.

should not forget the following quote: "Grace is given by God, but knowledge is bought in the market" (Clough 1819-1861). Foreign exchange is simply not available to purchase either the technology or data bases to run it. In other words, the transfer of new information technology incurs a cost that puts the developing country at a comparative disadvantage. This may be true in the short term, but only if the market were perfect. It is not, as described above. Therefore, no country can hope to develop and advance technology simply by accepting short-term comparative advantage. Most countries try to protect infant industries especially under threat of competition. The case for comparative advantage is linked to vested interests and political advantage. Developing countries are highly susceptible to package deals for purchase of technologies from industrial countries in the form of tied aid, kickbacks and economic promises of various kinds. A shift to basic production would disrupt international commercial operations. Therefore, the dependency relationship is firmly entrenched with modern market forces which have nothing to gain from the transfer of technology to developing countries. The role of donor assistance has to be carefully prioritized and implemented to avoid compounding the dependency relationship. Assistance to information projects will fail if attention is not paid to implementation procedures and sustainability. A minimum of ten years must be budgeted for to firmly entrench a research and information system in a developing country. One has to consider that start-up costs are necessarily higher than on-going costs. A team has to be found and put in place. Time must be allowed for the parent institution to become able and willing to bear the cost of running a service. Projects will fail where the technology is carelessly selected and where the project is badly planned and managed and is not co-ordinated locally according to national priorities. Very often decision makers seek out assistance from donors without a real appreciation of all the factors on which success will be based. Development best succeeds when society learns to make optimal use of its resources through application of science and technology to improve the living conditions of the population in ways consistent with national needs and priorities. In consideration

of this, it is very important to devise the means by which information and science and technology reach the ultimate beneficiaries and are not limited to urban elites in developing countries.

New information-communication technologies for developing country use must, therefore, be applied with the ultimate beneficiaries in mind. Otherwise, we run the risk of recreating the dependency relationship at the national level - rural poor dependent on the urban rich. To obviate this situation developing, micro-information environments should be considered at the grass-roots level to ensure the all-important feedback loop is closed. By giving the poorer sections of the economy a share in the information process, not only will this ensure a more equitable distribution of resources, but it will also create a situation whereby technology is applied correctly and viably. For this reason farmers, small-scale enterprises and village level workers require access to modern telematic facilities, including radio and satellite stations, micro-computers for field use and such other tools as may be deemed appropriate in a given situation; e.g., compact libraries utilizing CD-ROM at the village level. Television is now an almost universal medium; therefore, use of video to demonstrate techniques has much importance in some extension programs. Who determines appropriateness and how technology will be implemented are the two key basic issues. By emphasis on bottom-up development it will, hopefully, encourage the local pressure group for change at the decision-making level to successfully lobby for technical change. Strategies designed and created at the centre can only influence the periphery so far. The periphery needs to be activated and informed to maintain a momentum in the development process.

What Technology?

"Knowledge advances by steps and not leaps"

Lord Macaulay, Essays and Biographies, History (1828)

By emphasizing the question of national acquisition of new information technology, not enough attention has been given to what kind of technology should be acquired and who will use it. Much depends on the trade-offs between capital expenditures, training, research and education generally in terms of timescales. More detailed attention should be paid on the impact at the institutional and human level.

Information technology has been around a long time. Each new technology has had profound effects on the society involved in its transfer. It began with our first efforts to record ideas and evidence is found in the earliest civilizations. In China over three thousand years ago, attempts were made to systematically record knowledge on the oracle bones. Today, when we talk about the information communication revolution, we are increasingly talking about new tools and methods to handle information - a combination of computer based technologies, microelectronics, telecommunications and space technology; in other words, we mean mechanized methods to collect, collate, store, retrieve and disseminate information. A partial, though not exhaustive, list of such technologies might include:

computer graphics
computer conferencing
computer assisted software engineering (CASE)
desk top publishing
expert systems
geographical information systems (GIS)
local area networks (LAN)
machine assisted translation
management information systems (MIS)
optical and computer disks (CD-ROM)
packet switching
remote sensing and satellite imagery
telecommunications (FAX, E-Mail, etc.)

Some or all of these technologies are now in widespread use in many industrialized countries. From the developing country point

of view, we need to focus on those that are likely to have value, are transferable and can be viable under local conditions. At this point I will examine a few of what we might term "technologies of promise" and provide some examples of their utilization, problems as well as prospects.

Micro-Computers

The one technology we tend to think of as "new" is the micro-computer. Micro-computer use in developing countries is not really new. Computers have been in use in developing countries for some time with success.[1] Micro-computers are now quite widespread. Recently, it has generally been thought by some that the introduction of microchip technology would be the means for accelerating growth in developing countries by "leapfrogging". This theory was popularized by such writers as Arthur C. Clarke,[2] Toffler[3] and Soete.[4] This optimistic theory suggested that the industrial revolution could be by-passed by developing countries for an information society, decentralized, increasingly innovative and independent of transport with product substitution. Opposed to this was a group of experts who postulated the "grey skies" theory, such as Hilling[5] and Forester[6] who warned of such limitations to transfer of new

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1 S. Nilson, "The Use of Computer Technology in some Developing Countries", International Social Science Journal 31, 3 (1975), 513-524 (where it is stated mainframes have been used since 1960 including in Africa).

2 A.C. Clarke, "Third World 2001", South (Nov 1981), 13-15.

3 A. Toffler, The Third Wave (New York: Morrow, 1980).

4 L, Soete, "International Diffusion of Technology, Industrial Development and Technological Leapfrogging", World Development 13,3 (1985), 409-422.

5 D. Hilling, Infrastructure Gap in the Third World. Problems and Perspectives (New York: St. Martin's Press, 1979).

6 T. Forester, "The Myth of the Electronic Cottage". Futures 20,3 (1988) 227-240 who has also argued that psychological problems have been underestimated and that users have not found new information technologies cheaper or more convenient.

technologies because of such impediments as licensing agreements, restrictive practices and the infrastructure gap. Neither theorist has been exactly correct. Micro-computer use has become increasingly widespread in developing countries, yet it has not achieved the dramatic breakthrough predicted by writers such as Clarke. In practice, it is neither theory rather; it is as Lord Macaulay said: progress is a stepwise process, what we may also call the "trickle down" effect.

The enormous increase in reliability and environmental tolerance of the PC, together with the wide range of software alternatives, has slowly but surely put a powerful tool in the hands of the developing country researcher.[1] Some have been tested and applied in extreme field conditions and have been designed to provide rapid answers to questions posed by farmers seeking a variety of information on crops and cropping systems along the lines of "What should I do if.....".[2] With the successes abound failures.[3] The introduction of microcomputers has not, however, been general among developing countries. Despite their universal appeal and relative low cost, the level of computer use in Africa remains less than 5 per cent of the world's total. Nevertheless, decision-makers in African countries, as in other developing countries, are rapidly implementing computer literacy programs and almost every

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[1]H.D. Toong and A. Gupta, "Personal Computers", Scientific American 6, 247 (1982), 86-107.

[2]See, for instance, D.M. Etherington and P.J. Mathews, MULBUD, A Computer Package for the Economic Analysis of Multi-period and Multi-enterprise Farm budget (Canberra: Australian National University (ANU), 1984), 96 pp.

[3]According to one expert, the microchip could well distract the attention of Third World people from the issues of development. Attention should be paid to existing information, systems and efficient data collection. Efficient data collection must precede the introduction of a computer system otherwise disaster will result. See C. Raghavan, "The Barefoot Microchip. Treasure Chest or Pandora's Box", UN Development Forum (March 1983), p.6.

developing country has some involvement with microcomputers for economic development.

Given the transfer of computer technology for information management, the microcomputer can be a powerful tool in the development efforts of poorer countries by raising the level of communication at the basic level. The transfer of micro-computer technology must be approached carefully. Care and attention must first be paid to the local environment. It is important to improve the collection and handling of data and the training of staff. The problem of trained personnel is often pointed out as the most critical factor in the introduction of computers along with staff acceptance. Other factors include the provision of adequate funding, lack of software locally, poor administrative and service back up and lack of knowledge about the appropriate equipment for a given situation. In such a situation, education and training, as well as knowledge of the user community, is highly desirable.[1] Far too often, administrators are more keen on the prestige effect of having the latest equipment rather than approaching the problem from the job the microcomputers will be expected to accomplish efficiently according to a procedure analysis to improve the flow of data (compatibility, standardization of work flows and retrieval mechanisms). A major mistake often found in the developing country situation is of too much too soon. It is more important to begin with a modest system and expand rather than attempt to build in a large unworkable, unrealistic system from the beginning. More sophisticated technology can be added later. An incremental approach has the advantage of opportunities to latch on to later development, upgrades, etc.

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[1] See, for instance, Ta Huu Phong, "Computers in Forestry Research in Asian Countries", Journal of the Society of Research Administrators 19, 1 (1987), 13-15.

Low cost micro computers are ideal tools for solving the myriad problems formerly handled on behalf of developing countries by computer in industrial countries. For example, it was recently postulated that the increasing indebtedness of developing countries could be better controlled if greater control was exercised over methods of recording, handling and analysing information to a particular country's overall borrowings. The Commonwealth Secretariat studied the situation pertaining to a few developing countries for some time and came to the conclusion that an appropriate computer based program using available micro computer technology could help alleviate some of the problems. In a series of projects, the International Development Research Centre (IDRC) supported the development and initial testing of the software comprising a system called CS-DRMS along with the training materials. This system was launched as a pilot project in Sri Lanka and other countries with some success.[1] The micro-computer is also now highly suitable to a wide range of statistical uses including analysis of census data. For instance, IDRC also assisted the Latin American Demographic Centre (CELADE) in Chile to develop a micro-computer based software package for the creation, storage and retrieval of small area census data. Project participants are producing program documentation and user manuals in both Spanish and English and testing the software in the Caribbean as well as Latin America.[2] Micro computers are also an important training tool both for researchers, librarians and teachers. Used interactively to enhance learning abilities the course material can be replicated, modified and customized according to individual requirements.[3]

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[1]"Informatics as a Tool for Information Management in Development", prepared by the Information Sciences Division, IDRC, for the North South Roundtable on the Informatics Revolution and Developing Countries, Tokyo, Japan, 1-3 October 1987, (Ottawa: IDRC, 1987), p.11.

[2]Ibid.

[3]G.J. Papugiannis, "Information Technology and Education. Implications for Theory, Research and Practice". Manuscript Report C, Douglas, N. Williamson and R. LeMon MR161e (Ottawa: IDRC, 1987).

Telecommunications, Computer Conferencing, Electronic Mail System

The use of the computer for transmitting information is not new but its rapid application among the general population worldwide places it at the forefront of new information technology. Because on-line transmission of information is a tool accepted by the public at large, its transfer to developing countries is likely to spread fast in much the same way as portable radios. The transfer of this technology is also given a boost through local self-help mechanisms such as user groups and computer clubs. The transfer of this technology is also helped by public acceptance and enthusiasm for private exchange of information. Bulletin Boards are very popular. It has been estimated that upwards of 50,000 may be in use world wide. However, serious systems probably number 5,000, the majority of which operate in North America. (Smithsonian Magazine September 1988.) Such systems provide an instant window on the world or a soapbox for the general public. On the scientific level, there are many Boards such as Scinet, Omnet capable of putting a wide range of scientists in touch worldwide to compare notes on such issues as the global warming trend , the effects of acid rain or the Grand Unified Theory of theoretical physics. This is the ultimate invisible college in action. Bulletin Boards can also be a powerful educational tool. Class rooms can go on-line, and can connect abroad. Use of the computer as an educational tool is not, however, without problems, especially when one considers cultural questions.[1]

Computer based conferencing systems are a further refinement of this concept whereby groups of researchers located far apart can discuss a common topic, share ideas and dialogue pretty much as one would in a physical meeting with some limitations. The key to this is the use of the computer to store and retrieve conference content in what we term an asynchronous nature. Unlike the Bulletin Boards where users can communicate in both real and non-real time, conferencing participants usually

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[1]For an evaluation of this medium in developing countries see Papagiannis, op cit.

communicate using the computer in non-real time. The obvious advantage of this is apparent when one has to consider researchers located in different time zones being able to communicate and carry on with daily routines being relatively free of busy telephone lines. Moreover, it reinforces the invisible college by keeping people working in the same field in closer contact than would be possible by rare face-to-face contact. Computer conferencing, however, works best when a particular problem is the focus of the need to communicate, thus ensuring that triviality is avoided. The problems identified in developing countries that have hindered wider application of this medium include:

- poor local facilities especially telephone links;
- lack of access to reliable equipment;
- lack of training and access to training materials; and
- poor institutional support.

As an example of the situation facing a developing country, a pilot computer based conference system on the Bioconversion of Lignocellulosics was suppported by IDRC. Over 100 researchers participated in an eight month activity (May-Dec 1983).[1] The conference operated on two systems-Electronic Information Exchange System (EIES), Newark, New Jersey, USA; and COM out of Stockholm, Sweden-participation being through either system with exchange of information between both. However, one developing country participant located in Guatemala (Instituto Centroamericano de Investigacion y Technologia Industrial (ICIATI), had substantial equipment problems, e.g., modems, cables and software. The major problem experienced by ICIATI was lack of a good link locally to the international data transmission networks, a perennial problem experienced by many similar institutions in other developing countries. When it was

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[1] D. Balson, International computer based conference on biotechnology. A case study. (Ottawa: IDRC, 1985). Provides a detailed account of this experiment.

eventually made possible to link up with the international network, it proved to be quite costly utilizing regular voice channels. However, transmission costs have to be balanced against travel costs and work disruption. The benefits, from a scientific viewpoint, may be said to have outweighed the high cost of participation if one considers that: knowledge increased significantly about the subject (current thinking); their own research results were confirmed; the "invisible college" was consolidated; and future participation in international data transmission networks was enhanced.

Computer-based messaging systems (CBMS) or electronic mail (E-Mail) is beginning to have an impact on telecommunications in some developing countries. The system basically works by passing messages between different computers. One computer exists as a central node or "depot" collecting and distributing all messages. By logging-in a user is automatically informed if mail is available. The mail can then be read on the computer and, if desired, can be copied to other users. Other options include connection to data bases and bulletin boards. The means of access to E-Mail facilities is by the microcomputer with relevant software and modem. The main advantage lies in the relatively low cost of the technology. In industrialized countries, and increasingly in some developing countries, CBMS can be reached by a telephone call. The international data network is expanding rapidly. In the past two or three years several countries in Southeast Asia and Latin America have set up data networks. Rates have been reduced. For instance some network providers in the Philippines halved their rates in 1987. Those not able to connect to a network require a telephone call which is a problem in many developing countries. But better modems with higher speed and error correcting devices are helping to overcome this constraint.

National research institutes in developing countries are not able to participate as much as one would hope.

Scientists locally tend to have less exposure to computer technology and can't obtain technical help, although local user groups are growing. They also tend to have a smaller batch of international messages to handle and naturally almost all have little access to foreign exchange or local money to invest in CBMS. The situation varies in each developing country. Some scientists are situated in very remote areas, particularly in such places as the Sahel. Attention, therefore, must be given to different equipment and services that might be appropriate to enable more of them to link into a network. Donor attention is needed to this aspect of telecommunication facilities in developing countries. Solutions focus on the provision of fool-proof and user friendly equipment, most probably best depicted the lap-top computer because of its immunity to power disruptions and its portable nature.

The system would need software utilizing a simplified set of commands, most of which would take place when the system was not connected to the network, coupled with a mechanism to call up the user if it is not possible for the user to communicate with the system. The main constraint is start-up costs and experience. The service would need to operate in areas likely to be economically viable with a demonstrated demand. In Africa, for instance, a collaborative effort involving several remote locations would be necessary to develop a system. Such a system might "piggy-back" on existing systems such as CGNET (E-Mail communications service for international agricultural research organized by the Consultative Group on International Agricultural Research (CGIAR).[1] The project was completed in 1984 and resulted in the linking of some ten international agricultural research centres located in different parts of the developing world in a network mode, along with some of their remote outreach programs with which they conduct research. It is expected that as the system gains experience, it will be able to expand and include more remote sites in the developing countries.

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[1]"Telematics International. CGNET: A data transfer network for the CGIAR." Unpublished report submitted to the CGIAR and IDRC, November 1984.

Packet Satellite Communication

A further spin-off from space technology has recently become available by use of low-orbiting satellites. A major cost factor in satellite communication has always been in launch costs. Those satellites which go higher into orbit stay up longer and, therefore, have a longer life. However, they are correspondingly more complex and, therefore, costly. Recent experiences in some countries with launch capability, have shown the cost-attractiveness of satellites put up into lower-orbits. Though such satellites drop to earth sooner, they are ideal vehicles for computer-based messaging.[1] What this might mean for developing countries can be illustrated by collaboration between the volunteers in Technical Assistance (VITA) and the Radio Amateur Satellite Corporation (AMSAT) who in 1982 developed packet radio technology (PACSAT). This system was designed to improve communications in developing countries using low-cost and simple methods whilst aiming to provide a high volume of information transfer.[2]

Because it was not dependent on land-based telecommunications, universally experienced as the major limitation to communications in developing countries, PACSAT, was intended to open up a new era in cheap, relatively free flow communication in remote areas of developing countries. The system uses a small earth orbiting satellite which covers each point of the earth twice daily and is capable of acting as an electronic mail box receiving, storing

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[1]S. Ramani, and R. Miller, "A New type of Communication Satellite needed for computer-based messaging." 6th International Conference on Computer Communication. In: Pathways to the Information Society.

[2]M.B. Williams, (ed.), (New York: North Holland 1982) "Low Earth Orbit Satellites: Communication on the cheap." Paper presented at: Speculation on the barefoot microchip Colloquium organized by UN Development Forum 23/24 February. Paris 1983.

and disseminating messages in non-real time. Real time communication is also possible at the points where the satellite connects to ground stations. PACSAT holds promise but it is not without problems. Logistical problems aside, there are legislative hurdles to be overcome, bearing in mind the highly politicized nature of telecommunications technology in some countries. Bureaucracy, in some countries, also provides a barrier to the transfer of this technology since telecommunications often involves the decision and authorization of several ministries, not least, the military.

Expert Systems

Use of the computer to mimic the mental processes of human beings has provided experts with a fascinating area of research for some time. Originally contemplated as an offshoot of research into artificial intelligence (AI), expert systems are knowledge-based programs capable of using data, a knowledge base and a control mechanism on problems of sufficient difficulty that significant human expertise is necessary for their solution.[1] If one reads the literature on expert systems, on the whole it is optimistic. There are many successful applications in use mainly in the medical and legal field where abundant text book solutions or precedents exist for seekers of information to follow. However, there are not too many results in information science. Current research using expert systems in automatic cataloguing, for instance, has had mixed results.[2] The National Agricultural

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[1]N.S. Yaghmai, J.A. Maxin, "Expert Systems: A tutorial." Journal of the American Society of Information Scientists. 35 (1984), 297-305

[2]R. Meador & G. Wittig. "Expert Systems for automatic cataloguing based on AACR2. A survey of research." Information technology and libraries 7 (2) 1988 166-171.

Library in Beltsville, Maryland, USA has a project to use a micro-computer based expert system to help users get answers to specific agricultural questions. It is a small system built around reference texts likely to contain most of the answers people will be looking for. The system is linked to external programs providing on-line access to data bases of bibliographic citations (AGRICOLA both in BRS and DIALOG) and full text files that can give reasonable answers to basic questions rather than simply referral to set texts.[1] The more sharply defined and simpler a question is the more likely an expert system will be able to successfully answer it.

The advantages and disadvantages of such systems may be summarized as follows:

Human Expertise is	Artificial Expertise is
perishable	permanent
difficult to recall	easy to transfer
difficult to record	easy to record
unpredictable and	consistent
expensive	affordable

In addition to these factors we also have to consider the more pessimistic view of the human versus artificial intelligence inherent in such systems as follows:[2]

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[1]S.T. Waters Answerman, the expert information specialist: an expert system for retrieval of information from library reference books. Information Technologies and Libraries 5 (3) 1986 p.209

[2]Adapted from G. Lindsay, K. Novak and R. Bilodeau, "Information Technology in International Agricultural Research: Where are the payoffs? "Paper presented to the Annual Meeting of the consultative group on International Agricultural Research (CGIAR), World Bank, Washington, D.C., (1988), p. 18 (Quoted from original paper by Waterman 1986).

Human Expertise is	Artificial Intelligence is
adaptive	unoriginal
sensorially experienced	narrow focussed
broadly focussed	symbiotically input
commonsensical	technically based

In the developing country situation expert systems have been examined and found to be very useful, especially where access to expert advice is quite remote. A workshop sponsored by IDRC at the International Rice Research Institute (IRRI) in 1988 came to the conclusion that the greatest hope for expert systems in developing countries in the agricultural research area lies in provision of the missing elements in current information-communication of science and interface between researchers and the beneficiaries.[1] However, to make optimum use of such systems developing countries, in this case those of Southeast Asia, would have to share resources, particularly product knowledge.[2]

A major problem will always be in selecting the appropriate technology and adequate training of users, backed by user needs assessment surveys or end-use analysis. The practical uses of expert systems to developing countries lie in giving greater access to reliable relevant information from outside that can be used locally. Resources that previously might not have been considered possible to consult can be used. Links to CD-ROM, of which more will be said below, would make this technology an imaginative tool for national research and information systems and extension workers in developing countries. Greater delegation of work to junior staff might be possible since the junior researcher may be able to get further along in research without resorting to higher authority. As a training support,

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[1]J. Wilson, Report on the workshop on expert systems, Los Banos, Philippines, 27 June to 1 July, 1988, (Faro, Portugal: Knowledge systems, 1988), p. 8.

[2]Ibid p. 11

expert systems have an even more viable use.[1] Since expert systems explain their reasoning as they are used, they can help by establishing theory and relating this to practice by combining it with examples in use.

Optical Disks and CD-ROM

Of all the technologies of promise listed above, CD-ROM is probably the newest information technology that is widely known in developing countries. As a concept it has potential for developing countries and especially for those researchers working in remote areas with little hope of on-line access or other means to obtain information. CD-ROM has already been put into use and pilot projects and experiments have been carried out to test the applicability of the tool in developing countries. For instance, IDRC supported an eight-month evaluation in six developing country sites. A prototype product was used containing 14 months of bibliographic information and abstracts on agriculture. The evaluation showed universal acceptance of the tool.[2]

Compact disk-read only memory (CD-ROM) developed from audio technology. It permits the storage of enormous amounts of information on a small, durable disk. Each disk can hold data that would require 1500 floppy disks for the same amount of information. The information is first digitized, then optically accessed. The main advantage is the virtual indestructibility and error free data, unlike magnetic based systems. In-depth indexing permits access to a large amount of material in a relatively short time. From the developing country point of view, all that is needed to utilize CD-ROM is an IBM-compatible microcomputer and a CD-ROM reader, like a record player, an

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[1] Ibid., p. 19.

[2] J. Beaumont, "CD-ROM Evaluation Report.

interface card, cables and disks based on HSG. The process, however, is not cheap, nor are the outputs at the present time.[1] These are probably the two most limiting factors as far as developing countries are concerned. The process requires first the collection of literature to be put on the disk. If the literature is spread over a wide area and not in a single library, acquisition may be a long and costly activity. The literature is then digitized and a glass master is made. The up-front costs are very expensive and even though processing costs have come down recently, they are not exactly cheap. Hence only large, commercial companies with a stake in the information industry in industrialized countries have so far had the resources to commit to the procedure. The cheapness of CD-ROM lies in the production of additional disks after the first master. This is why the audio industry has capitalized on the CD-ROM medium as a profitable venture because of volume sales.

The advantages for developing countries lie in providing access to large amounts of data relatively cheaply and easily. A mile of shelving of conventional technical literature can be conveniently reduced to about a foot of shelving for disks. For a developing country remote from normal access to scientific literature, such a tool promises unprecedented access to relevant data bases. Creation of data sets in convenient form will help researchers interface their subjects more easily than ever before. Perhaps the most exciting possibility of CD-ROM

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[1]The High Sierra Group (HSG) provided the first standard format for compact disks in 1985. In future, as methods improve, new standards such as CD-ROM XA will permit developers to provide multi-media products and so combine audio visual and graphic output on one disk. While the technical production process is estimated to be about $10,000 for several hundred disks, additional disks could be cut for as low as $2. However, information processing costs and software development must be added to these costs.

technology lies in conjunction with use of expert systems mentioned earlier in this paper. Although most information retrieval systems can be considered adequate as a means for directing researchers to their topic and ultimately to answers to their questions, expert systems provide a quicker and more qualitative means of answering the researcher's questions. Such an interface would prove most useful in answering "how" and "where" questions of research. For instance, in crop and cropping systems research, a question about inter-cropping might relate to how much shade could be expected to affect a crop grown under the shadow of another crop. By creating a database that combined prior research results with data sets on relevant trials and a user interface that mimicked an expert on the subject, research time could be substantially reduced.

The disadvantages for developing countries have to be considered. Although cheap for use in industrialized countries, it is not so for the vast majority of developing countries, unless donor support is forthcoming.

Start-up costs for hardware and software, consisting of micro computer CD-ROM reader and accessories are estimated to be about US$8000. These costs will be reduced to about US$3000 if a suitable IBM compatible micro is available or an up-grade is necessary. However, lack of foreign exchange often precludes some countries finding even this small amount of cash upfront. However, the major limiting factor for developing countries will

be on-going costs and the high cost for subscriptions to data bases on CD-ROM, if they are available.[1] The annual subscription to the Aquatic Sciences and Fisheries Abstracts (ASFA) is $2070. CD-ROM is a read-only format so updating of information is not possible. The medium is best suited to researchers retrospectively. As an alternative to on-line searching, CD-ROM shows promise. However, to date, not only have the high cost of subscriptions been a barrier, but also the lack of suitable data bases on compact disk tends to preclude wider application in developing countries. The major data bases so far have tended to view CD-ROM as competitive with their hard copy sales.[2]

CD-ROM, as a medium for dissemination of information, works best when the data doesn't have to change much. Because it is read only, adding, updating to the disk is not possible. Data bases issued monthly are not really cost-effective unless heavily subsidized by other services. CD-ROM, therefore, is ideal for compact libraries where all kinds of reference materials, key texts, encyclopedias and dictionaries can be put onto one or two disks. For remote libraries this would seem to be the most promising feature. However, compiling such a compact library on CD-ROM requires a large investment.

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[1]There are several large bibliographic data bases for the sciences listed in the CD-ROM Directory, 2nd Edition (K. Churchill (ed.), London: TFPL Publishing, 1988), the average cost being about $2800 annually. However, the most persuasive argument we have today for decreasing the dependency relationship of the "South" on the "North" for sources of information relevant to development is the repatriation of scientific literature by emphasizing national and regional information sharing of local information. Much of the information on the CD-ROM at present relates to industrialized countries and the per unit cost of relevant local literature on these data bases can be expected to be quite high. A view also echoed by Beaumont op.cit. p. 14.

[2]Ibid., p. 42.

Developing countries experience grave difficulties obtaining copies of original documents. One answer may be in a project that has been under experiment for the past several years whereby publishers supply their scientific journals in machine-readable form for document delivery centres to print out individual articles on demand, and in the process obtain some income from interlibrary loans. I refer to the Adonis project now in its seventh year of development. The project has had many difficulties, including publishers pulling out of the project and inadequate technology. However, according to recent reports, the project is now making progress.[1] Trials are based on biomedical literature using CD-ROM. Articles are retrieved by optical disk and are then laser printed. As a future new technology, if successful, this form of document delivery could revolutionize developing country needs. The problem is cost. At present, only very large centres can be cost effective and an independent study at the British Library Lending Division indicated that the economics of setting up a document delivery centre from disks did not offer a distinct advantage on existing manual methods.[2]

After reviewing some items of new information communication technologies, it is appropriate to discuss how they fit into the economic development of poorer countries in terms of actual needs and requirements as opposed to perceived needs and requirements. Developments in technology and their impact are hard to predict because of the complexity and because recipients of new technologies react differently in various settings. A particularly important undertaking at the national level will be credible synthesis of economic planning and scientific research related to policy issues as a necessary pre-condition of adoption of new technologies. This is especially important considering the fact that relevant information about adoption and use is almost always scattered or hard to obtain.

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[1] R.M. Campbell & B.T. Stern, A. Adonis. A new approach to document delivery." Microcomputers for Information Management. 4, 2 (1987), 87-107.

[2] Ibid, p.91.

At what point in the technology revolution should developing countries jump in? Since technology is a moving target, each country will need to judge by individual needs. There is an inherent danger that because of particular circumstances in a given country, a wait-and-see attitude is adopted. The positive and negative aspects of CD-ROM in the developing country context is a good example of this. If we consider that floppy disks are to computers what the old 78 rpm records were to the phonograph, compact disks can be expected to quickly send the old phonograph record into oblivion. Within the next five years or so mechanical disk drives could also be replaced by data storing microchips. Instead of just using the microchip to process information, so the reasoning goes, why not let them store it too? Current developments include the new Dynamic Random Access Memories (DRAMS). Until recently, solid state memory had only a few specialized uses. Developments are so rapid that a new type of chip is already in use that holds out much more promise for the information industry than DRAMS. It is called the "ferro-electric Random access memory". Permanent memory is a big advantage over DRAMS and ferro-electric components give signals ten times faster and so it goes on. Does this mean we can soon discard disk drives?

A hundred years ago new technology was well spaced and much heralded and took many years to perfect. Currently, new technology abounds, survives a few years before being pushed off the shelves by newer products. It is doubtful anyone will ever remember the compact disk in a hundred years. The information industry is very competitive and although disk drives still have an important role to play, rotating memory systems are being developed very fast. Those countries with a strong semi-conductor industry are in a strong position, those weak in semi-conductor technologies need a new technological edge to survive. The next ten to twenty years will be very interesting indeed if we consider the developments in the post-war period.

Policies, Measures and Commitment

Understanding the forces of technical change associated with the introduction of new information technologies in developing countries involves different concepts and analysis. Information systems do not lend themselves very easily to conventional analysis, such as cost benefit. The conclusions can be very different depending on what position you take to analyse the situation. However, I believe it is important not to treat such change as a "black box" phenomena - something that exists outside the realm of the socio-economic system - rather new information - communication technologies should be conceptualized as part of the environment they operate in and may be looked at as social systems in which technology is merely one dimension of such systems. This social systems paradigm for information technology has been explored in developed countries such as England and it results in methodologies applicable to different organizations, contexts and cultures.[1] It is particularly pertinent to the developing country situation because the social system paradigm implies that information-communication technology in a developing country can best be understood in terms of the local environmental conditions in which transfer takes place. In this sense technology is a neutral tool but application can lead to both positive and negative effects. Exchange of information about adoption time is important to avoid duplicating mistakes. The lesson for information practitioners involved in the transfer of new technologies is to sensitize themselves to the cultural, political and social problems under which they operate.[2] A point also made by other writers.[3] The social systems approach can be approached through use of web models which can provide elemental structure for information systems and networks to deal with infrastructural problems.

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[1]G. Walsham, V. Symons and T. Waema, "Information systems as social systems: implications for developing countries. Information Technology for Development 3,3 (1988) 189-204

[2]Ibid. p. 202.

[3]Stone op.cit.

Developing countries, therefore, have to opt for the technology of the present that will best solve their own particular set of priorities; and, in doing so, must put in place all the component parts to sustain the technology. This immediately raises the broader question of how far should one expect a developing country to go in maintaining sustainability in technological change? How important should it be to emphasize national planning in the transfer of information-communication technologies? Should there be a case for the establishment of information industries in poorer countries of the South? For creation of semi-conductor industries, software development and value added communication services to ensure access to information at reasonable cost?

Some analysts (Stover) have argued strongly for developing countries to set such goals of self-reliance,[1] thereby reducing the dependency on the industrialized countries of the North by creating the conditions to produce their own hardware and software. This approach departs from the "trickle down concept" of technology to a "stock" concept. Some countries have over-emphasized the "stock" concept and have paid a high price in poor performance.[2] We should consider to what extent new technology developed in the North needs to be adapted and if local technologies can be a viable alternative. Two cases spring to mind in this context. China, after the Revolution in 1949 developed a vigorous policy of self-reliance linked with stringent isolation from all western technology. Although this policy evolved out of the bitter experiences China had with the imperialist powers immediately prior to the Communist Revolution, it must be noted at varying periods throughout her long history, China has embraced foreign innovations only later to eschew western technology. However, the policy of self-reliance reached its apex during the Cultural Revolution (1966-1976). During this

[1]W.J. Stover, Information technology in the Third World. Can it lead to humane national development? (Boulder Co.: Westview Press, 1984), 74pp.

[2]Dahlman op.cit., p. 769.

period, a period marked by intense developments outside of China in the information industries, China lost a generation of experience and in spite of a vigorous program to catch up and develop a modern information industry, the standard of information communication is generally thought to be at least ten years behind that of the United States and Japan in terms of hardware and twenty-years or more in software applications to China's problems.[1] India is often cited as an example of a developing country which has been able to develop its information industries in response to the principles of self-reliance. However, India has always adapted a pragmatic approach to technology. The importance of new technology to economic development has been emphasized in various national plans. Moreover, there has never been a policy of total self-reliance as in China. India has merely regulated the imports of foreign technology through a series of mechanisms such as licensing agreements which monitor foreign exchange, attempt equitable distribution, prevent monopolization and foster indigenous development. This is a complex task for a country so large and diverse as India and it is difficult, without evidence from specific studies, to ascertain the effect of India's policies on technology imports though general accounts seen to indicate a degree of success.[2] In the 1950's many developing countries chose this route in order to permit infant new technologies to grow until strong enough to compete with industries in more advanced countries. The effectiveness of such policies proved to be far from unqualified successes. Studies of Ghana in 1964 indicated 22 out of 31 new technology industries suffered massive losses.[3]

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[1]See for instance K.P. Broadbent, Dissemination of Scientific Information in the People's Republic of China, (Ottawa: IDRC, 1980, 148e).

[2]Piyush Kanfi Mahapatra, "New Technology in India.": In: K.R. Brown, (ed.), Challenge of Information Technology. (Amsterdam: North Holland, 1983), 263-272.

[3]K. Griffin and J. Enos, Planning Development (New York: Addison Weseley, 1970).

For the majority of countries in the developing world, the information industries will remain an underdeveloped sector for some time to come, but which, I believe should be stimulated further to help the development process.

Aside from questions of self-sufficiency and protectionist policies, it has been said that countries lacking a semi-conductor industry should not attempt to build computers. Ghana has been cited as an example of what can happen. Nevertheless situations change. Ghana has now eschewed the centrally planned economy model for establishing a new industrial base in favour of a more pragmatic approach that has involved freeing up some of the government bureaucracy where responsbility formerly lay in several ministries, has improved the decision-making process and has liberalized trade. Ghana is a large country but almost all its industry and service industries are located in a single city, Accra, choked with bad transportation and service industries. Ghana has been severely hit by the brain drain, but is now bouncing back. To deal effectively with the real world situation, it is doubtful Ghana or any other African country could afford to stake the up-front costs matched by Singapore whose current technology centre required an initial investment of USD 7.6 million. Singapore, moreover, is in a unique position to mix knowledge with talent. The development of information communication technologies do not come in tidy packages that fit traditional economies. What works in Singapore, will not necessarily work in Ghana. Institutions in developing countries must learn to share information and technical abilities widely across traditional barriers and systems. A particular area of concern is the problem of communication between information experts and those in supporting technologies. Improved communication across professions should be used as a first step to build better infrastructure.

Economic theory presumes that all alternative ways of producing something are known. What is known in detail are the production processes in use. We tend to know less about alternatives. These differences in degrees of information are crucial, because

the degrees of information are the important components to fill the gaps in the production function. It is a case of the old proverb "A little learning being a bad thing!", there being a basic amount of knowledge less than which cannot reasonably be acted upon. Everything depends upon the recipient of the new technology. If the recipient knows very little, they can do very little even with a basic knowledge because it is difficult to generate the complex detail that is often required to execute the total skill in the new technology. On the other hand, those who know a great deal and are capable of dealing with the complex details, then from just a small amount of information on the new technology, they will be able to act competitively on the rest. That is why it is hard to transfer new technology to many developing countries and not at all hard to transfer it to Japan.

In every economy, markets are imperfect. This is particularly true of developing country markets. There are big gaps in inputs where input is defined in this context to include information and motivation. This is where private entrepreneurs come in. They are energetic gap fillers and are a major factor in the information process where they apply knowledge and ideas into action. Activities in this information process at the technical transfer level involve the use of more skills, because not all aspects of new information technologies are easily transferable with any degree of ease. Five criteria can be identified in the transfer process listed in order from the easiest to the most difficult:

1. Equipment;
2. Services;
3. Skills;
4. Motivation; and
5. Management.

Developing countries having the least competence and infrastructures should consider this transfer process in the reverse order to be most successful.

There are big differences between countries everywhere when one considers technical capacity. Emphasis is, required, therefore, on such issues as investment policy as well as science policy -

in absolute terms the human and financial capacities of developing advantage for most efficient adoption of new technologies. Investment in local R&D, education and service sectors in developing countries remains weak because the need to absorb new technology requires a greater proportion of effort in the form of funds for training and R&D. This is demonstrated clearly by the big differences between developed and developing countries investment levels. In order to increase absorptive capacity for efficient transfer of new technology, it is necessary to put in place services and staffs to apply the technology. Developing countries on the whole are not doing this and as shown in Table 1, it is especially not being done in Africa. They are spending less and less on investments to increase their absorptive capacity. See below.

TABLE 2

Indicators of Technical Capacity

Indicator (% of World Total)	Industrial Countries	Developing Countries		
		Asia	Africa	Latin America
R & D Scientists	55.4	1.2	1.4	2.0
R & D Expenditures	66.5	0.31	1.60	0.94
Share of exports of capital goods	86.9	0.04	2.6	0.68
Developing Country Imports	90.3	0.1	5.1	0.53

Source: UNCTAD Handbook of International Trade & Development Statistics 1986 supp. UN Geneva.

World Bank Development Reports.

Apart from self-help and new domestic policy measures, the process can be speeded up by international cooperation especially South-South cooperation which would develop and promote national

capability for the production and utilization of local information technologies and mutual sharing of software applications between countries to avoid duplication of effort. Specifically, this solution might include such things as regional directories of experts, joint research projects, exchange of experts, seminars, conferences and workshops and joint efforts on such issues as compatibility and standards.

Summary & Conclusions

This paper has considered the impact of new information technologies on developing countries. It has argued that modern information-communication technologies are not different from any other new technology in the economic order. It is, therefore, appropriate to consider the transfer process from industrial countries in the light of historical experiences. History teaches us that developing countries began to miss out on the industrial revolution at a very early age and since then the gap has been growing at an alarming rate. Concentration of the information industries lies in the richer countries of the North whilst the most urgent issues in applied technology requires solutions in the poorer "South". Without access to new information technologies adapted to local needs the developing countries will fall farther and farther behind in world development. Various theories have been examined that suggest solutions. But without changes in policies at the national level that set agendas and priorities for information infrastructure, there is little hope for success. Donor agencies can assist with programs to buildinstitutional capacities and provide seed money for national information infrastructure, but it is important to reject any band-aid solutions which some have suggested, including donating obsolecent information tools to developing countries along with the experts to operate them. Developing countries must create their own programs from mandated national policies closely aligned to a science policy. It is strongly suggested that it is unrealistic for some poorer countries to act independently and build comprehensive information systems. The

route to be taken lies in regional co-operation and information sharing amongst groups of countries working to solve similar problems. This South-South collaboration should also benefit from judicious support of industrial countries in the application of new technologies deemed appropriate in consultation with the developing countries.

The issue at question is our ability for social creativity, for information sharing and technical collaboration. We have discussed how the new information-communication revolution can exacerbate disparities, but it also holds out a great deal of promise for equitable growth in the area of North-South relations. It requires an effort to make the new technology serve the interests of developing countries in an ever increasing interdependent world.

This requires us to assist, where possible, in the transfer of new information communication technologies to developing countries by first understanding the processes of technical change in the social context thereby avoiding many of the mistakes of the past. In this way, new technologies can be the effective tools they are meant to be when placed correctly into an acceptable infrastructure carefully aligned to local needs and priorities.

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