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The Global Information Infrastructure Revisited

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ABSTRACT *Ideally, the internet will eventually evolve into a global information infrastructure, which, by creating a global information marketplace, will narrow the poverty gap and eliminate many of the existing geographic barriers to prosperity and equality. On the other hand, there is a risk that the internet will concentrate economic activity among the richer countries and thus accentuate the existing divisions between North and South. Which of these scenarios is the more likely will depend to a large extent on whether developing countries are able to gain access to low-cost forms of information technology. Using numerous examples of such technology that already exist in the Third World, we conclude that there is in fact more scope for optimism regarding the Global Information Infrastructure than is commonly realised.*

In a recent article in this journal Linda Main (2001) points to two opposing scenarios regarding the impact of the internet on inequality between rich and poor countries. On the one hand, 'The hope has arisen that this internet … will ultimately evolve into a Global Information Infrastructure (GII). The vision is that the GII will enable a massive acceleration of economic and social development that will narrow the poverty gap and eliminate many of the geographic obstacles to prosperity and equality' (Main, 2001: 85). On the other hand, however, given the tendency of the internet to concentrate activity in one particular group 'there is a real risk that we are moving towards a two-tier technology society that perpetuates the old distinctions between North and South' (p 83).

Which of these scenarios is the more likely, depends, as Main rightly points out, on the availability to developing countries of the technological infrastructure that the internet requires. In this regard, however, she focuses almost exclusively on just two types of enabling technologies, namely, undersea cable systems and satellites. And in so doing, I will argue, she neglects a wide range of other forms of information technology that—on account of their low cost—may enable at least some developing countries to lessen the digital divide that separates them from the advanced countries. The purpose of this paper, accordingly, is to describe these other technologies and, on the basis thereof, to suggest that there may indeed be more hope than Main allows for the internet to evolve ultimately into a Global Information Infrastructure.[1] It is well to emphasise at the outset, however, that, although they may differ in a number of other respects, the tech-

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nologies considered below all have in common the goal of lowering the cost or extending the life of proprietary innovations first developed in and for advanced country markets. The extent to which this objective is reached is so crucial because we entirely agree with Jhunjhunwala (2000) when he argues that 'Low-cost innovative IT solutions are a must if IT is to make a mark beyond the top few percent of the population of developing countries'.

The genesis of low-cost information technology

As Rodriguez and Wilson (2000: 10) have rightly emphasised: 'The information revolution started in today's developed countries, so it makes sense that these countries have higher levels of technological attainment and higher use of ICT products'. It makes sense because it is true of innovations in general that they tend to reflect and fit in with the socioeconomic circumstances of the country or countries in which they originate. In the developed countries, for example, where innovative activity has historically been heavily concentrated:

> High rates of capital formation and relative labor scarcity have led also to extensive investment in human as well as physical capital, producing well-educated and skilled labor forces … The very success of this industrial growth has been the creation of societies whose high income levels offered large markets for industrial products. These economies were thus able to devise and exploit technologies involving very large fixed investments as well as highly skilled labor forces. They depended for their success upon extensive markets of affluent consumers in order to justify the economies of large-scale production that had come to characterize much of their industrial plant.
>
> Thus, modern industrial societies have developed technologies whose main features broadly accord with the special characteristics of their historical growth paths. (Rosenberg, 1988: 14–15)

It is equally true, however, that over the past few decades or so some large developing countries, such as India and Brazil, have built strong technological capabilities in certain areas, including information technology, and these capabilities refer not merely to the ability of scientists and engineers to reproduce technologies from the West, but also to their skill at generating entirely new products and processes (as evidenced, among other ways, by the desire on the part of major multinational corporations to employ local personnel in R&D facilities established in such parts of the Third World).[2] By a line of reasoning that is entirely analogous to the case of developed countries as described above in the quotation from Rosenberg, one can expect that innovations originating in the developing countries will tend to embody characteristics that are more suited to low-, rather than high-income societies. (Note also in this regard Stewart's observation that 'local costs and resource availability unavoidably influence technology design, even when there is no conscious intention to achieve this' (Stewart, 1979: 98).

More specifically the innovations in question are likely to cost less and to fit in more readily with the local environment (in terms, for example, of infrastructural requirements) than similar products imported from the developed countries. It is no accident, therefore, that many of the low-cost information technologies that

we describe below emanate from the industrially developed parts of the Third World such as India and Brazil, although we also identify cases where such technologies take the form of products developed earlier in the now industrialised countries and which on this account are also likely to conform more closely to the contemporary conditions prevailing in the Third World. In still other cases there are institutions located in the developed countries (such as NGOs or international organisations) which are specifically charged with the task of designing low-cost information technologies for the benefit of users in poor rather than rich parts of the global economy.

Low-cost information technology and the Global Information Infrastructure

Although we fully recognise that they are in many ways interdependent rather than independent, it is nevertheless convenient to organise our discussion around two distinct categories, namely, digital telecommunications technologies and computer hardware and software. Innovations in both these areas, we feel, are likely to have a major bearing on the extent of future internet use in developing countries.

Telecommunications

Even with the emergence of digital as distinct from mechanical technologies in the telecommunications sectors, issues of cost still dominate the task of supplying telephone access to rural areas, characterised more often than not by low average incomes and low population densities (urban areas, by contrast, are generally far better served by fixed line telephony). In response to this problem Indian engineers managed to produce a number of important innovations that, in terms of cost among other socioeconomic characteristics, are far better suited to local conditions than the comparable technologies available from the developed countries. It is worth emphasising that the appropriate inference to be drawn from these examples is not that Indian research efforts necessarily produce innovations of this type. After all, there are numerous instances where, for example, research capabilities in that country have led instead to new global products designed to meet the needs of multinational corporations to satisfy high- rather than low-income markets (Reddy, 1997). The point is rather that Indian engineers are capable of generating low-cost innovations even in complex areas of information technology, when that is their specific objective.

Consider from this point of view the earlier of the two cases that we shall describe in this section, a process which had to do with the design and manufacture of small-scale digital exchanges for rural areas. As expressed most clearly in the words of the engineer who at the time was most involved in the project, the goal was not merely to leapfrog from mechanical to digital switching technology but also to make the latter suitable for Indian villages (97% of which in 1980 had no telephone at all). 'My message' he wrote,

> was that India should abandon electromechanical switching and move immediately toward digital systems for switching and transmission. My reasoning was twofold.

> First, electromechanical switching was ill-suited to the Indian climate and to Indian conditions. With few available telephones, most lines were intensively used, and electromechanical equipment was much more likely than digital to malfunction from overuse. (We later discovered that some public phones in India generate as much as 36 calls per hour at peak volume, compared with maybe 10 to 12 in the United States.) Electromechanical switches are also more vulnerable to dust and moisture. Analog transmission, finally, suffers over distance, while digital transmission is what gives those astonishingly intimate connections halfway around the world. In a country with low telephone density like India, distance—and therefore static—were nearly unavoidable. Second, the development of digital technology would help build native industries in electronics, software, and related fields. Moreover, India needed one piece of digital equipment that no other country manufactured but that many developing nations could use: a small rural exchange. In the United States and Europe, the smallest exchange built will accommodate 4000 to 10 000 lines, and, in small towns and rural areas, these exchanges are installed and then deliberately underutilised. This kind of waste may be tolerable in a country where the number of small exchanges is tiny. In India, exchanges with a vast overcapacity would have to be installed in hundreds of thousands of villages … Development of an efficient exchange for 100 to 200 telephones would not only solve India's problem, it would give the country a valuable high-technology export (Pitroda, 1993: 70).

What emerged in the late 1980s, then, was not only a low-cost 128-line rural exchange (about which more below), but also one that in certain other respects as well was well suited to Indian conditions. A low-cost solution needed to be found, for example, for the tendency of digital switches to overheat when the electrical system malfunctions (a notoriously common occurrence in rural India as most elsewhere in the Third World). The solution that ultimately emerged, according to Pitroda (1993: 70) was:

> simple but ingenious. First, to produce less heat, we used low-power micro-processors and other devices that made the exchanges work just slightly slower. Second, we spread out the circuitry to give it a little more opportunity to 'breathe'. The cabinet had to be sealed against dust, of course, but by making the whole assembly a little larger than necessary, we created an opportunity for heat to rise internally to the cabinet cover and dissipate.

At a price per line, which (at around Rs 1500) is regarded as 'one of the lowest for digital switches anywhere in the world' (http://www.voicendata.com), 25 000 of the small-scale rural exchanges that emerged from the so-called C-DOT project (http://www.cdot.com) have subsequently been installed in the rural areas of the country. And when one considers in addition the fact that the technology has been exported to some 12 other, relatively poor, developing countries (mainly in Africa), it is difficult not to see in this project an important example of how low-cost information technology developed in and for developing rather than developed countries, can help to lessen the global digital divide (and hence raise the likelihood that the internet will evolve ultimately into a Global Information Infrastructure).

Much the same can be said, it seems, of another, more recent attempt by Indian scientists and engineers to adapt modern telecommunications equipment to local conditions and by extension to other developing countries as well. This initiative,

unlike the one we have just described, involves a technology known as 'wireless local loop' (WLL) which was conceived originally to provide narrowband telephone service in developing countries that lacked a telephone infrastructure. WLL is in fact a system that connects subscribers to the public network by means of radio signals rather than copper for part or all of the connection between the subscriber and the switch. As in the digital switching case, however, WLL has also (much more recently) been adapted by Indian engineers with a view to making it cheaper and more accessible given the circumstances prevailing in the rural areas of the country.[3] Known as 'corDect' the modified WLL,

> is all set to usher in a rural telecom revolution in Indian by paring the cost of rural telephony by well over 50 percent, besides pegging the maintenance cost including power charges to a bare minimum … The project, started in January this year [2000] has wired 50 villages … successfully without using a single centimeter of copper wire … WLL, using the radio communication platform, connects the subscriber to the main exchange by radio waves instead of traditional wire loop … In the case of rural connections, while the cost per connection using conventional technology will be in the range of Rs 40 000 to well over Rs 130 000 in the remote villages with rocky terrain, the cost per telephone using the … WLL technology will cost only Rs 17–18 000 per unit. (http://www.financialexpress.com)

As with the Indian-designed digital switching technology described earlier, 'corDect' is being used in a number of other developing countries. In particular, 'the technology has now been licensed to a few companies in … Singapore, Tunisia and Brazil', while 'Systems are operational in Madagascar, Fiji, Kenya, Tunisia, Argentina and Nigeria' (http://www.tenet.res.in/cordect.html).

Still other innovations designed to bring information to isolated areas in rural India have emerged from projects associated with the well known M S Swaminathan Research Fund. The Village Information Project in Pondicherry, for example, employs a 'value addition centre' (where staff working in a centrally located village scan the internet for useful information) as the hub of a local area network based on Very High Frequency (VHF) radio. The 'value addition centre' serves so-called information shops in other villages which in turn are equipped with a Pentium personal computer and an inkjet printer.

The PC can be connected to the wireless network through a modem and a specially designed interface. Each shop also has a board to display bulletins received via email from the value addition centre … The shop volunteers, at their discretion, write in more news from the locality. The shop also enables a visitor to make a voice (phone) call within the region (http://www.mssrf.org).

What one should conclude from the various examples in this section is not that the digital divide between India and the developed countries is about to be breached in the near future. On the contrary, the challenge still remains a formidable one with a great deal that remains to be done. The main point is rather that there appears to have emerged in that country, 'an independent, indigenous telecom industry which is capable of providing affordable internet access solutions and which reduces the need for imports as the telecom infrastructure rapidly expands' (Stata, 2000: 1). Still further support for this conclusion will emerge in the following section where we describe the case of the Indian 'Simputer'.

Computer hardware and software

In the developed countries innovations in computer hardware and software are closely related over time, with much of the causality running from changes in the latter to changes in the former. Generally speaking, that is to say, the causal pattern is one in which ever more sophisticated software programs demand new forms of hardware that are faster, more powerful and exhibit a wider range of design features. As shown in Figure 1 this tendency can be depicted in terms of a constant shift to the left of the rays representing computers of later vintages (we have selected the three particular vintages shown in the figure somewhat arbitrarily). These later vintages are viewed as embodying an ever higher proportion of what on the vertical axis we refer to as sophisticated characteristics, as opposed to essential or basic characteristics shown on the horizontal axis (which, again for the sake of argument, we have assumed to be equal to OX, an amount which would include, for example, word-processing capabilities, data filing and other such relatively basic characteristics).

Given the tendency for the global software standard to change relatively frequently, the outcome of this process, inevitably, is the rapid obsolescence of computers that are tied to this standard, with consequences for the environment that are well described by O'Meara (2000):

> Computers present a tremendous disposal problem—in part because they become obsolete so quickly. A recent study by the US National Safety Council estimated

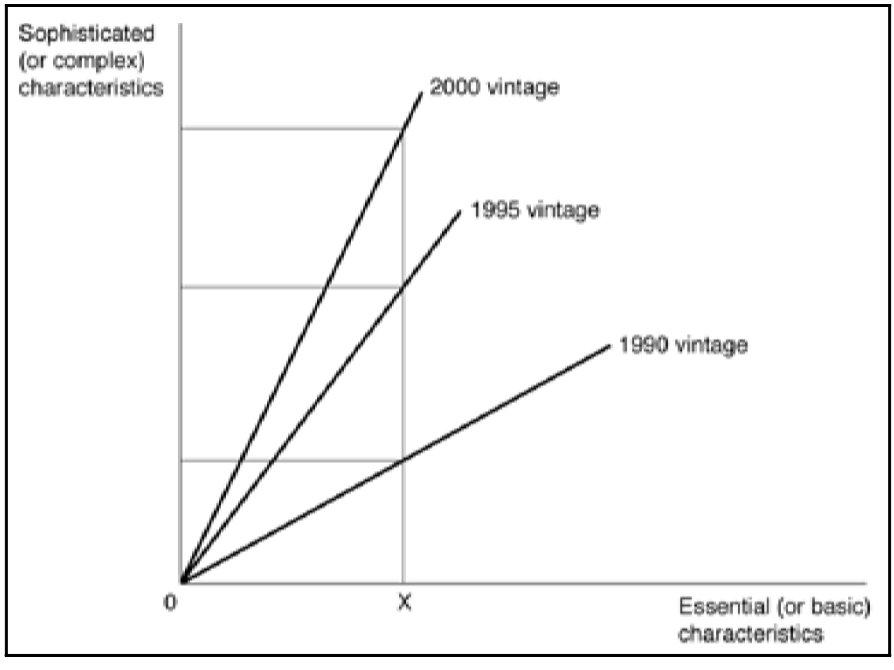

FIGURE 1
The changing characteristics of computer hardware innovations in developed countries

> that 20.6 million personal computers became obsolete in the United States in 1998—and of these, only 11 percent were recycled and 3 percent were resold or donated. Because computers become outdated rapidly, repair is costly compared with the price of new goods. When computers are trashed, the lead in monitors, the mercury and chromium in central processing units, and the arsenic and halogenated organic substances inside the devices all become health hazards. Recycling of computers … is difficult because most are not designed to be recycled (O'Meara, 2000: 127).

From the point of view, however, of users who require only the basic characteristics of a computer, such as a typist for whom only the word-processing function is relevant, or school children learning the basic elements of how to use computers, the hardware thus massively discarded in the United States (and developed countries more generally), can accurately be regarded as 'prematurely obsolescent' (it is obsolescent, in other words, only in the very special sense that it is incompatible with the most recent software developments). Indeed, for such groups of potential users it is precisely the low price per *essential* characteristics of these older computers that makes them attractive. (In terms of Figure 1, such preferences tend to be met by products such as the 1990 vintage embodying a relatively high proportion of essential to inessential characteristics.)

When pursued to its logical conclusion, the line of reasoning contained in the previous paragraph suggests the need for a process whereby the computers regarded as obsolete by one group of users can be made available at low cost to other groups, especially but not only in developing countries. The scope for such an approach has been emphasised in the Indian context by Jhunjhunwala (2000), who points to the important role played by second-hand television sets in getting cable television so rapidly to the rural areas. He estimates that second-hand Pentium computers may be made available in India for as little as US$125 to $200 after tax, a price which ought substantially to hasten the adoption and diffusion of these products. In South Africa a company called 'Africom' (http://www.highwayafrica.org.za/pages/africom.html) is providing refurbished computers at a price of between $300 and $400. 'Africom' has an arrangement with a US-based organisation which receives a nominal amount for cleaning the hard disk drives of the used computers (which, upon arrival in South Africa, are refurbished in Cape Town by a group of some 40 employees). 'Most of the computers are Pentiums, which are used in such companies as General Electric and banks, as well as post offices' (Ngoro, 2000). Africom's goal is to supply 16 000 computers per month as opposed to the existing number of 1000 and its intention is to supply these to schools. Still another attempt to supply the demand for second-hand computers is being made by the recently established 'Green PC Inc' (http://www.newdealinc.com) whose mission 'working with PC manufacturers, leasing companies and other PC refurbishers, is to provide a complete, internet ready PC solution with unmatched functionality and price to its chosen markets … The result is that Green PC Inc can offer unprecedented computing power, ease of use, and cost effectiveness with its internet-ready sub-$300 line of computers' (http://www.greenpc.com).

The lifespan of 'obsolescent' computers can also be lengthened by a deliberate inversion of the causal relationship between software and hardware that was described above in relation to developed countries (and was summarised in

Figure 1). Thus, instead of a process whereby software is designed in such a way as effectively to shorten the working lives of computers, one could conceive of an alternative process in which software is designed instead to *lengthen* the life-spans of computers that would otherwise be discarded as obsolete (and to this extent also alleviate the environmental problems that were seen above to flow from what according to one perspective can be regarded as 'premature' obsolescence).

Just such an idea has in fact already been commercially exploited by a US-based firm called 'New Deal Inc', which has developed software for personal computers 'with a design approach of "sustainable software" that enables it to enhance functionality without regularly obsoleting existing hardware' (http://www.newdealinc.com). More specifically, this type of software is 'able to run effectively on any PC, from the latest Pentium III to the earliest 286 PC'. A recent educational software program designed by the firm, for example, contains all the applications that are required to teach basic computer literacy and internet use and yet requires only a 286 processor, 640K RAM and 9 MB of hard disk space. When one considers that in the USA alone there are said to be more than 30 million functioning computers that could be donated to schools, it is difficult to overestimate the impact that this innovation could have on computer literacy in developed and developing countries alike. (With regard to the latter, there are already said to be significant New Deal initiatives in place in southern Africa, the Middle East, Brazil and India.) To this already sizeable potential should be added the fact that the use of open source (as distinct from proprietary) software can also serve to prevent the premature obsolescence of computer hardware in developing countries. In the Philippines, for example,

> A number of local schools are discovering that Linux [open source software] can save them from inevitably increasing their tuition fees every time they have to upgrade their computer systems. Educators who discussed the advantages of Linux in schools … agreed that this free open-source operating system that can run on low-end machines can free them from the financial bounds of commercial software distribution and upgrades.[4]

What remain to be discussed in this section are the various attempts that have been made specifically to design low-cost computers, as distinct from the efforts described above to refurbish or re-engineer already existing models. And as we shall see, there is a similarity here with the case of telecommunications in that *a number of such innovations have emerged from the developing countries themselves.* Consider first the so-called 'Simputer', which was jointly designed by the Indian Institute of Science and a private company based in Bangalore, with the avowed goal of bringing the internet to 'the masses' in India and other developing countries (http://www.simputer.org). Priced at below $200, the 'Simputer' will offer non-literate users the chance to browse the internet using pictures, and its text-to-speech capability will also allow the web content to be delivered in local languages. According to one source, 'the designers have been able to achieve the sub-$200 price point since the electronic components used in the device are all off-the-shelf volume components, and the software is primarily open source software such as Linux' (http://www.pcworld.com). (Note in this

connection the more general point that expensive proprietary software packages are not necessary for many applications. Linux, for example, is being installed in some 140 000 computer laboratories in Mexican schools, while Schoolnets in South Africa are said to rely exclusively on public domain e-mail software and mail servers.) A second example has to do with the low-cost computers ($200 to $250) that emerged from a Brazilian government initiative designed to widen access to the internet among the poorer segments of the population (http://www.nandotimes.com). According to Brazil's Minister of Science and Technology the new computers (using simple software) are expected to bring the internet to some 23 million users, a figure which, even if somewhat optimistic, would make an appreciable contribution to lessening the digital divide in that country.

Unlike these two innovations, which emerged from within and for (markets in) the Third World, the final case we shall mention is of a so-called network computer developed by a corporate spin-off of the US software firm 'Oracle' (http://www.oracle.com). Lacking a hard disk drive and running on open source Linux software (rather than the customary Windows operating system), this device is also expected to sell at an exceptionally low price (less than $200). These computers are equipped with a 56K bit/sec modem and a Netscape web browser which are sufficient for access to the world wide web. The first such products 'will target educators and provide students with a more affordable alternative to a PC for accessing the internet and e-mail' (http://www.nwfusion.com).

Taken together, all these innovations seem to suggest that, in the design of low-cost computers, the role of open software appears to play as crucial a role as does the versatile New Deal software in rejuvenating older products that might otherwise be discarded.

Conclusions

Whether the internet will ultimately evolve into a Global Information Infrastructure, which will eliminate many of the geographical obstacles to development and equality is a question that has recently been addressed in this journal by Linda Main (2001). In her attempt to provide an answer, however, she focuses on just two types of enabling technologies (undersea cable systems and satellites) and in so doing, we feel, neglects a wide range of other forms of information technology that, in principle, raise the likelihood of the internet evolving ultimately into a Global Information Infrastructure.

We have emphasised that some large developing countries are now capable of generating information technologies for their own relatively low-income markets rather than being entirely dependent on developed country markets (indeed, a number of innovations that were described above were designed in India specifically for the socioeconomic conditions prevailing in that country). We also noted the potential benefit for developing countries of computers that are discarded in the more industrialised countries merely because they are incompatible with the latest versions of proprietary software.

Obviously, the supply of these and other forms of low-cost information technology does not guarantee that they will actually be adopted on a large scale in

the Third World. What also needs to be considered is the demand side of the issue and in this regard there are numerous factors that are known to mitigate against the choice of this type of technology. For one thing, in many developing countries there tends to be a bias in favour of the 'latest' technologies and against older versions which are regarded as 'outdated' and 'obsolete'. On the other hand, some of the innovations we have described are so radical that it is difficult to conceive of them not affecting the lives of millions of users in developing countries, be they in schools, villages or industry (I am referring here, for example, to internet computers that will be available for less than 200 US dollars).

Notes

[1] Parts of this paper draw heavily on James (2001).
[2] For a full discussion of this point see Reddy (1997).
[3] For a full discussion of the various institutions involved in this innovation see the world wide web site of the Indian Institute of Technology, Madras (available at http://www.tenet.res.in).
[4] From the article 'Computer world Philippines: freeware OS attractive to schools' (available at http://www.linuxtoday.com).

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