Prometheus, Vol. 26, No. 2, June 2008

Time-Intensive Information Technology and Human Welfare in Developing Countries

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Abstract *This paper is concerned with the scope for developing countries to benefit from the Internet in non-synchronous ways that is, in cases where some delay is involved in the delivery of information, as compared with the real-time alternative used in developed countries. The first part of the paper draws on insights from Becker and others, to argue that poor people in poor countries are wont to exchange (relatively abundant) time for reductions in the cost of Internet use. The second part of the paper then examines whether such time-intensive products actually exist and to the extent they do, how the required degree of cost reductions are effected in practice. I conclude that time-intensive Internet technology represents a highly promising opportunity for developing countries to close the digital divide, an opportunity that warrants serious academic scrutiny.*

Keywords: appropriate technology; digital divide; synchronous versus asynchronous time; welfare-effects

Introduction

Despite rapid growth in the use of mobile phones in developing countries—most notably in sub-Saharan Africa—the task of bringing the Internet to those countries remains a formidable one. Such progress as has been made with this latter form of information technology seems to be heavily based on adoption by relatively educated, affluent and urban users drawn from the formal sector of what are often described as the technologically dualistic societies of the Third World. According to Bhatnagar, for example, more than 80% of Internet use in India is concentrated in 12 large cities. Similar patterns have been observed in other developing countries[1] and they follow from the fact that those living outside the formal sector of these countries do not usually possess the attributes mentioned above as being conducive to Internet adoption. Since technical change in information technology occurs overwhelmingly in the industrialized countries, that is to say, it fits much better into

Prometheus ISSN 0810-9028 print/ISSN 1470-1030 online © 2008 Taylor & Francis
http://www.informaworld.com/journals
DOI: 10.1080/08109020802029760

the formal than the non-formal (mainly agricultural) part of technologically dualistic societies.

Some efforts have been made to design Internet-based technologies that are better suited to this latter sector. One can point for example to low-cost hardware (such as second-hand refurbished computers) and software (such as open-source), as well as to institutional innovations that rely on sharing mechanisms rather than individual ownership of new technologies (with telecentres being perhaps the best example in this category). Useful as they are, however, these examples are limited by the restriction that Internet access has to take place in real-time (or immediately) as it almost always does in the developed countries. Yet, as I seek to argue in this paper, immediacy in the supply of information is not likely to be valued nearly as highly among the poor majority in developing countries, who are likely to prefer instead a more 'time-intensive' technology in return for lower access costs.

If this is indeed so, it is to the cost or supply-side of the argument that one needs then to turn; for, it is one thing to denote the type of product that is required, but quite another to show how this can actually be done. So doing, I further suggest, should take into account four distinct channels through which non-synchronous modes of Internet connectivity allow the use of factors that belong more to developing than developed country technological systems. The case studies that also form part of this section then illustrate which of these channels (or combinations of channels) are used in actual practice.

The Demand Side

The notion that time is valued as a function of income needs to be viewed in the broad historical context of technical changes in products, where these are viewed, following Lancaster,[2] as bundles of embodied characteristics (such as taste, texture, calories in the case of foods).

Since almost all technical change in products originates in and for developed countries, it is to them that one should look in order to understand the direction of change over time. According to Stewart,[3]

> Technical change in products in developed countries occurs with the rising incomes (and is partly responsible for those rising incomes), so that the balance of characteristics offered by new products corresponds to the changing demands of consumers as their incomes rise. The rising incomes have the effect of shifting demand towards different products with more sophisticated, labour-saving, higher-quality, etc. characteristics: to summarise this complex of changes we may say that the characteristics of the new products have more high-income characteristics.

The tendencies described in this quotation can be neatly summarized diagrammatically as shown in Figure 1.[4]

The figure depicts a situation where the two characteristics on the axes are described as high and low-income. Goods are portrayed as rays from the origin, combining the characteristics in different proportions. How far along each ray a consumer can go is dependent on the price of the good and her given money income. The direction of the arrows indicates that over time products contain an increasing ratio of high-to-low-income characteristics. Corresponding to the

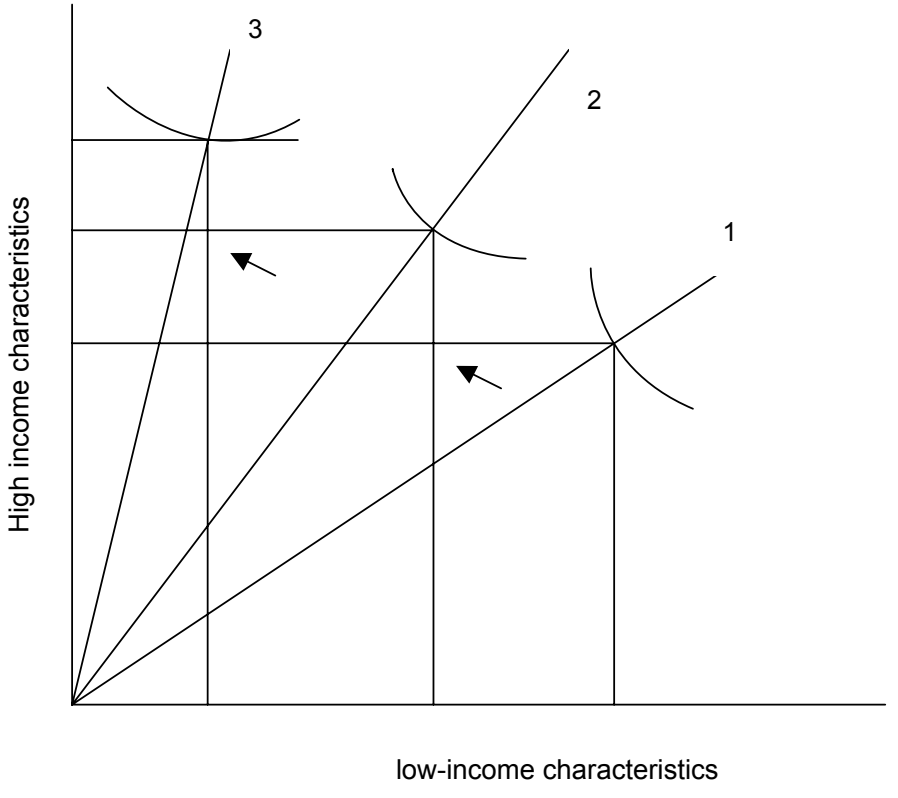

Figure 1. The direction of change in product characteristics over time.

change in this ratio are changes in the preferences of consumers as their incomes rise over time, as represented by the slopes of the indifference curves in favour of high-income characteristics.

Time can be considered as a 'high-income' characteristic in that its value increases with higher wages and so too does the incentive to economize on it (as exhibited for example by innovations such as microwave ovens, pre-cooked food and freezers). Becker[5] has made most of this recognition, arguing that

> The incentive to economise on time as its relative cost increases goes a long way towards explaining certain broad aspects of behaviour that have puzzled and often disturbed observers of contemporary life … *time is used more carefully [in developed countries] than a century ago.*

Simply put, the argument advanced by Becker assumes that the value of an hour equals average hourly earnings and thus that there is a one-to-one correspondence between earnings and the value of time (see the lower panel of Figure 2). Again for the sake of simplicity, I assume a linear relationship between the value of time and the intensity with which this characteristic is embodied in products. Thus, when hourly earnings and the value of time were relatively low in the history of the industrialized world, products tended to embody a relatively high proportion of time (shown illustratively as OY in the figure). As earnings increased so too did the value

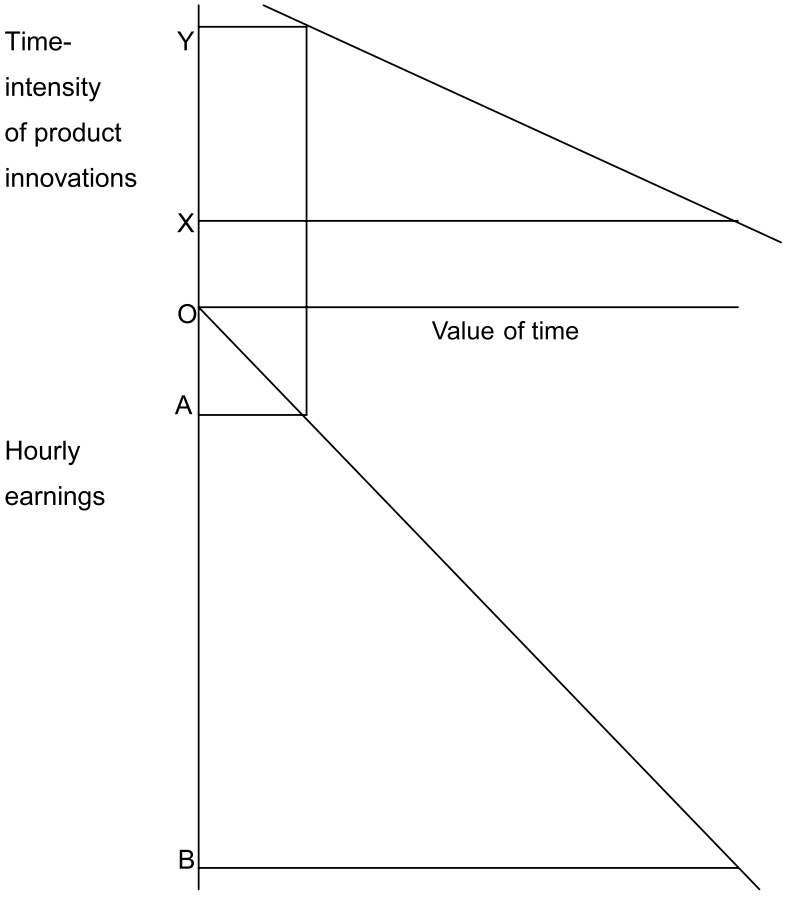

Figure 2. Time, earnings and the direction of technical change.
Source: J. James, *Information Technology and Development*, Routledge, London, 2004.

of time and the amount of this characteristic embodied in product innovations declined (to say OX).

I have focused thus far only on the developed countries where global R&D and product innovations are overwhelmingly concentrated. The direction of technical change in products is almost entirely dictated by the circumstances prevailing in those countries, as suggested in Figure 1. If, however, innovations happened, for one reason or another, to be directed towards the poor majority in developing countries, a very different pattern would emerge, one in which there was a radically altered proportion of high-to-low-income characteristics. The 'bottom of the pyramid' idea is relevant here and in particular the recognition that multinationals and other firms can only serve the poor profitably if they make ultra low-cost (but well-functioning) products. The Indian firm 'Nirma' is one of the best examples of how this can actually occur. In particular,

> 'Nirma' was able to effect remarkable cost reductions, which at the end of the 1980s, enabled the product to be sold at less than half the price … of the then leading laundry detergent. … 'Nirma' does not contain characteristics such as

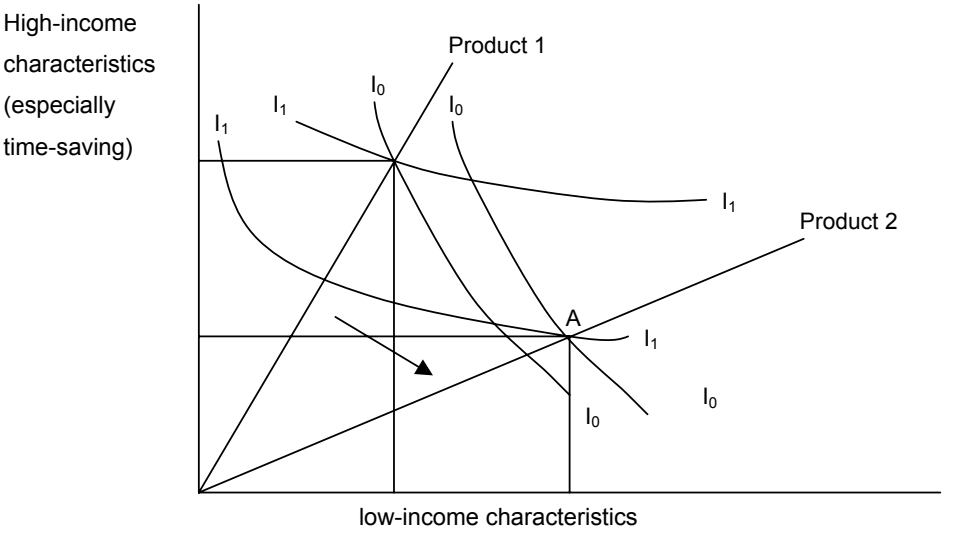

Figure 3. Time-intensive technical change.

> optimal whiteners and scents, or ingredients designed to reduce the harshness of the product on hands and fabrics. … Whereas the [high-income] products are packaged in heavy cardboard, on which there is also sophisticated and expensive printing, 'Nirma' is sold instead in simple plastic bags on which the printing is relatively crude and hence much less costly. In short, therefore, 'Nirma' may be said to retain just those characteristics of modern laundry detergents that are necessary for it to function effectively.[6]

With respect to the use of time, this general line of argument would point in the direction of product innovations for poor people that *use* rather than *save* this characteristic. Effectively this would reverse the pattern show in Figure 1, with the new situation depicted in Figure 3.

Beginning thus with the high-income time-saving product 1 and the associated pattern of indifference curves (I_1I_1), technical change moves in the direction indicated by the arrow of *time-using* product 2, with the map of indifference curves shown by I_0I_0. Assuming that the two indifference maps belong to rich and poor consumers, respectively, this altered direction of technical change induces an increase of welfare for the latter but not the former (point A, that is to say lies on a higher indifference curve for the I_0, but not the I_1 map).

The Supply Side

I have so far simply assumed the existence of a relatively time-intensive product such as 2 in Figure 2, in order to focus on the demand side of the issue. That product, one should emphasize, by being more time-intensive than the alternative, reduces costs sufficiently to be accessible even to groups in remote, rural areas of developing countries (I emphasize the group aspect because it is already abundantly clear that the Internet cannot realistically be made available to single individuals or households in these countries, even with ultra low-cost computers).

Table 1. Source of cost savings in non-synchronous methods

Channels	Examples
1. Hardware/software innovations	Local computer designs, open-source software
2. Blending the Internet with traditional modes of communication	Radios, telephones
3. Relying on other available local resources	Labour, transport and other resources
4. Reducing or eliminating real-time Internet requirements	Bandwidth, speed of computer

But the question then arises as to how the necessary cost savings are actually going to be realized in practice.

As shown in Table 1, I identify four channels through which non-synchronous modes of Internet connectivity can promote cost savings as compared with the real-time alternative.

It is true that hardware and software innovations can also be part of real-time Internet systems, but what I am referring to under the first mechanism are innovations that are peculiar to non-synchronous methods. The second and third categories convey the idea that the latter methods allow the use of various local inputs that better fit in with developing countries and partly as a result are cheaper than the inputs required by the real-time alternative. (Note that in contrast to the third very general category, the second is specifically about blending the Internet with earlier more traditional modes of *communication*.) The final mechanism captures the idea that real-time technology is a complex system made up of numerous fixed parts which are not readily substitutable. (There are, that is to say, 'technological linkages between different parts of the system which mean that much of technology comes as a package, which cannot be separated and introduced bit-by-bit, but which goes together'.)[7] When the real-time system is replaced, however, some parts will disappear or become less demanding. The common theme that underlies all four mechanisms can be stated in simple neo-classical terms. It is to facilitate the substitution in developing countries of relatively abundant and hence cheap resources (including time) for relatively scarce and hence expensive ones.[8]

The mechanisms just described should not be considered mutually exclusive. Rather, any particular combination of them might be present in a particular context. Indeed, it is hoped that the case studies will throw some light on the extent to which they are jointly in evidence.

The Case Studies

As listed and classified in Table 2, the case studies chosen for this paper are meant purely as illustrations of non-synchronous Internet projects in developing countries. They do not require any technical background and indeed are notable for the comparative simplicity of the way in which they operate. My intention is to set the cases in an economics rather than an engineering framework. In fact, to be included, project descriptions were required to pay at least some attention to the costs that they entailed.

As shown in Table 2, there are four categories representing, respectively, mobile access points (using physical carriers for intermittent Internet access); courier delivery methods (of physically transporting digital storage for asynchronous connectivity); blending the Internet with traditional modes of communications; and

Table 2. A classification of the case studies

Type of project	Name of project	Country	Innovating institution
Mobile access point	DAKNET	India	NGO/university
Courier data delivery	Wizzy Digital Courier	South Africa	School system
	Drishtee	India	Private firm
Internet blending	e-Post	India	Postal service
	Kothmale Radio	Sri Lanka	Community radio
Other types	TEK (e-mail queriable)	Developing countries	University
	Wizzy Digital Courier (delayed dial-up)	South Africa	School system

the last category containing cases that do not fit into the other three. As I proceed with my discussion of the cases in the order in which they appear in Table 1, I shall be trying to address two basic questions. The first is about the extent of cost savings that has been attained (as compared with real-time or other low-cost alternatives), while the second deals with the mechanisms through which any such savings have been attained (the mechanisms, that is to say, that were listed in Table 1).

1. DakNet

Arguably the most prominent example of non-synchronous Internet connectivity for developing countries, this project does not eschew the use of broadband, but it well illustrates some of the mechanisms described in Table 1 and it certainly yields remarkable cost reductions. DakNet is best described by its founders in the following terms.

> As an implementation of very low cost asynchronous ICT infrastructure, we have developed a store-and-forward wireless network for rural connectivity … The DakNet wireless network takes advantage of existing communications and transportation infrastructure to distribute digital connectivity to outlying villages lacking digital communications infrastructure. DakNet combines physical means of transportation with wireless data transfer in order to extend the Internet connectivity provided by a central uplink or Hub (e.g. a cybercafe, VSAT, or post office) to kiosks in surrounding villages.
>
> Instead of trying to relay data over a long distance (which can be expensive), DakNet transmits data over short point-to-point links between kiosks and portable storage devices called Mobile Access Points (MAPs). Mounted on and powered by a bus, motorcycle, or even bicycle, the MAP physically transports data … between kiosks and a Hub (for non-real-time Internet access) … By employing short-distance radio links, DakNet allows for small low-cost low-power radio devices to be used.[9]

Insofar as the transporting vehicle (say a bus) is covering the same route as it otherwise would and the village kiosk happens to be a school, DakNet is relying on transport infrastructure (including of course roads) that already exists. The project also relies on 'inexpensive Customer Off-The-Shelf hardware components, open-source software' and the low-cost, low-power radio mentioned in the quotation. These seem to be the main reasons why DakNet is described as being 'orders of magnitude' cheaper than four other types of communications infrastructure:

Table 3. A comparison of five types of communications infrastructure (infrastructure cost/line)

	Rural (US$)	Remote (US$)
Copper	3,957.75	4,185.31
Cellular	616.52	2,600.09
Wireless local loop	201.04	848.83
Fixed wireless	67.01	281.45
DakNET	0.67	2.90

Source: A. Hasson, *United Villages: Connecting the Next Two Billion for 1$ per Villager*. Available at: http://www.United_Villages-Overview-Feb-2007-ppt, accessed 6 February 2007.

copper, cellular, wireless local loop and fixed wireless broadband.[10] The precise orders of magnitude are shown in Table 3, which compares the infrastructure cost per line in rural areas (at least 40 kilometres from backbone communications infrastructure) and remote areas (at least 80 kilometres).

2. The Wizzy Digital Courier

Designed specifically for the rural parts of the South African school system, this project makes use of the fact that once freed from the real-time constraint, one does not need a 'live' Internet connection to derive the benefit of this technology. Indeed, the Wizzy Digital Courier works even in the many isolated schools that have no telephone line. The system is based instead on the physical movement of data between schools such as these and a location which does have a regular Internet connection. More specifically,

> It is a system that involves physically transporting data saved on a USB memory stick back and forth between one central computer … and unconnected machines in outlying areas … Using a program … designed with open-source software, the school can compose e-mail messages and specify topics for an Internet search. Then it can send a teacher or a gardener off—by bicycle, perhaps—to plug the memory stick into a central computer miles away, upload the current batch of communiqués, and retrieve the results of yesterday's requests.[11]

In its best-known form, where the chosen courier is a milktruck that would anyway make the round of schools, the Wizzy Digital Courier makes the same intensive use of the existing transport infrastructure as the buses in the DakNet project that already serve the villages in question. The costs of the former endeavour have been described as 'minimal', consisting mainly of the wages paid to the truck drivers to carry out manual data transfers (in this way too therefore, making use of an existing and inexpensive local resource, relatively unskilled labour).

3. Drishtee

Drishtee, a privately owned e-government enterprise in India, uses the same basic idea as the Wizzy Digital Courier of physically transporting data between two computers in the absence of a telephone connection, the logic in both cases being

that 'When large quantities of data need to be moved and *time lag is not a key consideration*, it often makes more sense to transport data on [for example] CDs'.[12] At Drishtee a computer in the government centre has an Internet connection and it receives from and sends data to the village computers by the physical transfer of floppy disks. How far other parallels exist with the South African example, however, is difficult to say without further information.

4. e-Post

Though some of the projects included in the sample contain elements of blending digital and traditional forms of communication, in this and the next case study, blending is the *central* element. e-Post is an initiative of the Indian Postal Service that effectively provides non-synchronous e-mail services to people without home computers (indeed, users of the service do not even have to send the mails themselves). In particular, what occurs is that customers initially hand a postal worker a message destined for a snail-mail address. The postal worker then types the message into a computer and e-mails it to the post office nearest the designated recipient, where the message is printed out, placed in a sealed envelope and delivered by a postman in the normal way. Since its introduction on a pilot basis in 2001, the service, which then cost 21 US cents, has been scaled up to the national level and is indeed available at any post office in the country (India, one should note, has an exceptionally high number of post offices per head of the population).[13]

The low-cost of the e-Post service is due largely to the use of existing resources, be they post offices with computers or the postmen who deliver the e-mail message in the same way as they do other letters (with the blend, as I have defined it, being between the Internet on the one hand and snail-mail communications on the other). The ability to use these local resources, however, derives ultimately from the asynchronicity of the process. (The sender of the mail, that is to say, does not enjoy the instantaneity that goes with owning a computer but does nevertheless benefit from the cost savings induced by a slower mode of transmission, involving as it does, a number of stages. What he or she gets, lies, in effect, between direct e-mail on the one hand and snail-mail on the other.) In this respect, the project can well be described as intermediate technology, in the sense used by early proponents of this form of technology.[14]

5. Radio Kothmale

This once well-known project, now said to be non-operational,[15] used a blend of the Internet with another traditional form of communication, namely, the radio. Via so-called radio-browsing programmes, where presenters literally browsed the Internet on air, listeners were able to get answers to the questions they posed either through snail-mail or a personal visit to the station itself.

> Presenters first select relevant reliable websites and broadcast the programme with local resource persons as studio guests (e.g. doctors for a health programme) who discuss the contents of the mostly English-language sites directly in the national languages. They also describe the websites and explain how they are browsing from one web-page to another. *Thus, listeners not only get the information they requested, but they understand how it is made available on the web.* They can respond to the programme and they know that essential data will

> remain available in the community database if they wish to make individual use of it.[16]

To much the same extent as in e-Post, therefore, Radio Kothmale relied on local resources that were already in existence (e.g. community radio stations, technically skilled presenters, snail-mail), or in the case of the volunteers on the programme, were provided at no cost. Thus it was that listeners in the area were able to gain non-synchronous information from the Internet for the price of a postage stamp.

6. TEK ('Time Equals Knowledge')

In contrast to the case of DakNet described above, which also originated from research at MIT, TEK ('Time Equals Knowledge') was designed specifically for people with a slow Internet connection. At its simplest, the idea is that information can be gained from the Internet inexpensively and non-synchronously, on the basis of a regular e-mail account.

> Compared to direct Web access, e-mail can be *much cheaper*, more reliable and more convenient in developing countries. The TEK client operates as a proxy on the user's machine, enabling users to browse downloaded pages using a standard Web browser. New searches are automatically encoded as emails and sent to the TEK Server [in Boston], which queries the Web and returns the contents of resulting pages via email.[17]

> During the program, the selected Web-pages are simplified and compressed in order to reduce bandwidth requirements, which, as noted above is a key distinguishing aspect of this highly promising innovation (now freely available software distributed under the GNU/LGPL licence).

7. Wizzy Digital Courier (Delayed Dial-Up)

Both the Drishtee and Wizzy Digital Courier cases described above under the heading 'courier data delivery', arose in response to the lack of telephones in remote, rural areas of developing countries. This example, also from Wizzy Digital Courier in South Africa, is based instead on the situation where these modes of communication are in fact available. It relies all the same on a simple, yet cost-effective idea.

> Instead of dialling up during the day, each outbound email and each request for websites is stored on the server until 7 pm … whereupon the server dials up and downloads the day's outbound traffic. It then spends the entire night downloading email and entire websites that have been previously requested by the teacher.

By switching from the standard to the less-expensive overnight rate, the school saves 50% on its phone bill.[18]

In Table 4, I summarize the case studies from the point of view of the questions posed at the outset of this section, having to do with the costs and the source of savings associated with non-real-time modes of Internet connectivity.

Table 4. A summary of the case studies

Project	Delay relative to real-time	Project cost for user	Main source of cost savings
DakNet	1 day	'Orders of magnitude' lower than other types of communications infrastructure.	Reliance on existing transport infrastructure; off-the-shelf hardware and open source software; used in existing schools and low-cost, low-power radio.
Wizzy Digital Courier	1 day	Minimal. 'Both Wizzy and DakNet have the key advantage of being *significantly cheaper* … than, other technologies.'	Reliance on existing transport infrastructure (milktrucks, drivers); open-source software; use of inexpensive manual data transfer.
Drishtee	1 day	Minimal.	Reliance on local transport; use of inexpensive manual data transfer.
e-Post	± 1 week	Marginal cost near zero. Cost of e-mail only 20 US cents.	Based entirely on existing postal service (post offices and snail-mail)
Radio Kothmale	± 1 week	Marginal cost near zero. Cost of asking questions zero.	Use of volunteers and existing community radio station with Internet browsing programme.
TEK	1 day	Available as free software.	e-mail queries cheaper than regular Internet browsing. Compression and simplification of selected web-pages reduces bandwidth requirements.
Wizzy Digital Courier (delayed dial-up)	1 day	Nightly rates on telephone calls. A 50% reduction compared to daily rate.	Switching from real-time, regular telephone charges to nightly rates. Use of existing school computers and Internet connectivity.

Incomplete as it obviously is, the evidence does nevertheless suggest that non-synchronous methods can be a means of gaining the benefits of the Internet at a remarkably low cost (with a sacrifice, in most cases, of only a day). In the first three projects, the school or village has a computer without Internet access while in the next two cases the beneficiaries use no computer whatsoever. Only in the last two examples do the users actually have a 'live' Internet connection, which is used non-synchronously to 'exchange time for money'. Partly on account of this heterogeneity, the ways in which cost reductions are effected also differ (as shown in the last column of Table 4). TEK, for example, is about reducing bandwidth requirements whereas DakNet relies on broadband and uses other methods of obtaining cost reductions. The blending cases rely on traditional modes of communication, whereas others save costs by using the local transport infrastructure, including the labour input that transfers data between two computers. In spite of these and other differences, however, one characteristic is common to almost all the cases, namely, that they rely heavily on local rather than imported resources of one kind or another (the use of time in other words goes together with a relatively dated technological system that is also intensive in local resources already in use). This is very much what one would expect of time-using innovations designed specifically for poor rather than rich countries.

Conclusions

So far as I am aware, this paper represents the first attempt to specifically discuss the topic of time-using innovations in information technology for developing

countries. What one now mostly finds are descriptions of particular innovations in this category rather than attempts to take on the concept as a whole. This tendency towards fragmentation makes it difficult to bring the topic to the forefront of debates on bridging the digital divide. I have argued above that the notion of time-using innovations in the context of the Internet warrant so prominent a position on the agenda on theoretical and empirical grounds, having to do with both demand and supply (the more so indeed because many other ways of bridging the divide have not achieved what was originally expected of them).

The paper began by following and elaborating on Becker's idea that the value of time is positively related to individual wages and earnings, a line of argument which led ultimately to the conclusion that poor people in poor countries would tend to sacrifice time in exchange for relatively low-cost ways of delivering information via the Internet. This suggestion was pursued in the second part of the paper by asking whether such products actually exist and (if so) how they are able to bring about cost reductions of the required magnitude. In spite of differences between projects in this regard, one characteristic was common to all of them, namely, a heavy reliance on local rather than imported resources of one kind or another. My hope is that this somewhat tentative attempt to classify and compare different forms of using the Internet in non-synchronous time will stimulate further debate on the idea as a whole. Rigorous evaluations of these technologies would be especially welcome.

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