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Editorial correspondence: see "Editorial Team" above

Advertising correspondence: <novatica@ati.es>

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IT and Disabilities

Braille and The Pleasure of Reading: We Blind People Want to Continue Reading with Our Fingers

Carmen Bonet-Borrás

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This paper was first published, in its original Spanish version, under the title “*El Braille y el placer de la lectura: los ciegos queremos seguir leyendo con los dedos*”, by **Novática** (issue no. 169, May–June 2004, pp. 67–72). **Novática**, <<http://www.ati.es/novatica>>, a founding member of UPENET, and publisher of UPGRADE on behalf of CEPIS, is the bimonthly journal and magazine of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática*, <<http://www.ati.es>>.)

In this article the author describes her long experience as a user of Braille, the language for the blind, and of other technological aids for the blind. The author expresses her love of Braille and her conviction that, in spite of all the major technological advances there have been in this field, Braille will continue to be an essential tool for the human and intellectual development of people who suffer from visual impairment, and a gateway to enjoyment and culture.

Keywords: Braille, Blindness, Personal Experience, Digital Technologies Aiding the Visual Impairment, Visually Impaired People.

1. Presentation

This article is based on my personal experience over many years as an IT professional and a user of special tools for the visually impaired due to my having been totally blind since the age of six (see photo of the author in



Figure 1: Photo of The Author at Age 6, for Her ONCE (Spanish National Organization for the Blind) Card.

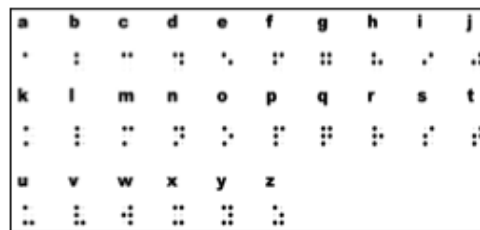


Figure 2: The Alphabet Braille – Spanish Version (Source: The Caragol Foundation).

Figure 1). I am, therefore, an experienced user, though I am not an expert in disabilities and new technologies.

2 What Is the Braille System?

When in the first half of the 19th century, while he was barely an adolescent, the Frenchman Louis Braille laid the foundations for the system of reading and writing named after him, the Braille system, a code in which letters are represented by raised dots (Figure 2), he could not have suspected that nearly two centuries later it would still be a sufficiently interesting and topical subject to be worthy of your attention in this journal. During the intervening time, blind people all over the world have been using the Braille method to read and write, and no other system has ever threatened to replace it. And, in my opinion, this is no accident; the fact is, the system is hard to improve on. For those of us without sight, what could be better than to read with our hands and, our fingers being the way they are, we are not equipped to use

smaller or thinner letters, or use characters of a more complicated design.

I remember the **Optacon** (Optical-to-Tactile Converter), which was probably the first device to put electronic technology at the service of blind people. It was, and in fact still is (I still use mine) a machine developed in 1963 at Stanford University, California, by Prof. John Linvill, which worked by scanning printed paper and making hundreds of little

Carmen Bonet-Borrás has a BSc in Mathematics from the *Universidad Complutense de Madrid*, Spain. She is Systems Engineer at IBM España, member of ONCE (*Organización Nacional de Ciegos de España* – Spanish National Organisation for the Blind), and member of the Working Group on Informatics and Disabilities of the Spanish CEPIS society ATI (*Asociación de Técnicos de Informática*.) <carmen.bonet@is.ibm.com>



Figure 3: The Optacon Device (1978 Version).

pins in the shape of the letters vibrate on a pad under the user's index fingertip (Figure 3).

However, this device had a very short life; it came on the market in the late 70s and was useful to some of us for a while. It was the tool with which I started out on my career as an IT professional, although, in spite of its great intrinsic value as a tool enabling blind people to read printed texts directly, it did not really catch on, mainly due to its poor performance. Because of the complex shape of letters and the variables created by varying print quality, different types of paper, etc., the reading speed attained by most users was not high enough to meet their everyday needs. And over time, new developments offering access to reading materials have taken its place.

Meanwhile, Braille lives on.

And not only does it live on, but it has been given new life, has been renewed and is growing under the influence of the new technologies. The arrival of computers gave rise to the idea of computerized Braille and whole new horizons opened up. The number of different characters which can be represented by 6 dots is 64. For literature, by using the trick of sometimes doubling up characters, this was enough, but for computer use it is simply not sufficient. For a start, doubling up characters is not viable because it causes an imbalance between the original text and the Braille representation (screen, Braille display), which could create problems, and there are also far more characters to represent. The solution was to switch to an 8 dot Braille system, giving 256 characters, which is another kettle of fish altogether.

But there is an unresolved issue concerning Braille: each country has drawn up its own character correspondence table and there is an urgent need for these tables to be standardised and for the differences between one country and another to be ironed out as soon as possible. I recently heard that the ONCE (*Organ-*

ización Nacional de Ciegos de España – Spanish National Organisation for the Blind, <<http://www.once.es>>) is addressing this problem, so I expect some progress to be made in this area soon.

Innovative new ways of producing the raised dots used in the Braille system are also being tried out. The normal method up until now has been to perforate the paper, but there has been a constant search for alternative methods which, little by little, is bearing fruit. The application of new serigraphic techniques, whereby tiny drops of very special plastic substances are stuck to the paper in order to achieve an equally legible relief printing effect, is particularly interesting. This technique is being used for visiting cards, for example, and it may be a good alternative for certain situations such as labelling on cardboard, or for other cases where the text is short and repetitive.

2.1 Who Uses Braille?

Braille is a reading and writing system for all visually impaired people whose residual vision is not sufficient to make use of the methods available to people with unimpaired sight. We should also include in that group visually impaired people who, while still able to manage a pen, have been diagnosed as having a certain risk of their residual vision being reduced or lost altogether.

It is true that there is a certain relation between age and the difficulty of learning Braille due to physiological reasons, since the sense of touch of an adult's finger does not develop in the same way as that of a child. This may give rise to a degree of resistance in some adults with acquired blindness, to the extent that the sense of touch of a person who goes blind very late in life may not even develop enough to cope with Braille at all. But, in any event, everyone should try to learn it, since everyone, whether blind or sighted, should be able to read and write. We should do everything in our power to prevent adults who lose their sight from becoming what we have come to call *functional illiterates*; in other words, people who know how to read and write but are unable to make use of that skill. We should therefore make a special effort to break down the resistance to learning of sufferers of late onset blindness, and involve and commit them to learning Braille by making every possible resource available to them.

There is another group of people for whom the use of Braille is even more vital. These are the deaf and blind, for whom listening as a substitute for reading in order to access the written word is not an option.

Another group of blind people who would find life very difficult without Braille are musicians and music students. Musical notation is complex enough to begin with, but when it comes to converting all the information contained in a five-line staff into dots, I cannot even begin to imagine what it would be like 'listening' to an entire score.

2.2 Braille and Daily Life

But is Braille so important? Braille is by turns convenient, necessary or indispensable, from first thing in the morning to the last thing at night. If, as I believe we should, we intend to give blind people the greatest degree of self sufficiency in their everyday life (as in any other facet of life), such self sufficiency will be all the more viable and real the more knowledge they have of their environment and the less they have to depend on the help of a sighted person.

So, if the first thing we do after getting up is to get under the shower, what better way to start the day than by being able to identify the shower gel or hair conditioner by its name, printed on the containers in Braille by the manufacturers? If I have two similar pairs of trousers and I don't want to put the wrong pair on by mistake, the one which doesn't go with the coloured sweater I've picked out to wear, wouldn't it be good if easily confused clothes could be labelled in Braille with their colours? If I want to choose between full fat and semi-skimmed milk, or pick out the CD I want to listen to, I have no option but to label them, in Braille of course, because I can think of no other way round the problem. And so on, throughout the whole day.

Packaged foods, canned and bottled foods, soft drinks... should all reach the shops appropriately labelled in Braille, especially medicines due to the particularly dangerous consequences of a mix up.

With perseverance and effort, and by using our memory to the full, trying to be very ordered and systematic, and inculcating the people with whom we live with the same attitudes, we can alleviate the problem of not being able to read. But there can be no doubt that the correct identification of the things around us would be a major contribution to our quality of life.

This idea is far from being a fantasy. Products from brands such as Pescanova (frozen foods) or Doña Jimena (confectionery and biscuits), Sanex (soap) or some models of Newpol washing machines, plus a number of medicines, have turned this idea into a reality. We need to keep up the pressure so this becomes the rule rather than the exception. A good example to follow is that of lifts: there is a regulation regarding safety measures,

dimensions, the control panel... and it is nice to be able to go to a building and reach the door you want without it having to be on the ground floor.

It is up to blind people to be skilled in Braille and benefit from this effort. That way we can avoid having to change the menu at the last minute because that can of tomato sauce we opened for spaghetti turned out to be green beans. Reading, as a gateway to culture, study and as a leisure activity in general, plays an important role in everyday life, and if you can read in Braille, so much the better.

2.3 Reading by Listening

Isn't listening to a talking book reading? If we look up the Spanish words *leer* (read), *oír* (hear), and *escuchar* (listen) in the Spanish Royal Academy dictionary, 2001 edition, we find the following definitions:

Leer (From the Latin *legere*).

1. Vb tr. To look at something written or printed while understanding the meaning of the characters used.

2. Vb tr. To understand the sense of any kind of graphic representation. To read the time, a musical score, a plan.

3. Vb tr. To understand or interpret a text in a certain way.

Oír (From the Latin *audire*).

1. Vb tr. To perceive sounds with the ear.

Escuchar (From the vulgar Latin *ascultare*, Latin *auscultare*).

1. Vb tr. To pay attention to what is heard.

We can see that according to the first two definitions of the word *leer* (read), the answer to the above question would be no, but according to the third definition the answer would be yes. Far from being contradictory, the two answers are in fact complementary. It is a matter of addition, not confrontation. The most important thing, over and above any other consideration, is to access information, and if we are discovering the literal content of a book, there can be no objection to calling that reading, whatever the method used to access a book. Nevertheless, since everything is relative, I would choose listening as better than nothing, but I would go for reading over listening every time.

Ideally each user would be able to choose, something which doesn't happen very often. After many years' experience of doing both things, I am in no doubt about my priorities and I have to admit that, although there may be occasions when I decide to read by listening, these are few and far between, because you can get into a book more by using your hands than using your ears.

Human beings are characterised by our ability to think and express ourselves through language. Reading and writing, together with

speaking and listening, are the ways we express ourselves through language, ways which we should not and cannot give up. Reading with our fingers makes it possible for us to read at our own pace, with our own intonation, and allows us to appreciate the style and content of what we are reading, thereby creating that dual link with the written word that cannot be achieved by any other method. When we read with our ears, firstly we are deprived of knowing how something is written, and secondly, we lose a certain amount of the content, since the text has already been partly 'interpreted' by the person reading it out loud. And worse still if it's a machine reading the text (a technology already in an advanced stage of development); then we will have all the functionality we need, but as for pleasure...

In my case at least, if what I have to read is even slightly complicated, includes a large number of figures or requires a certain degree of analysis, memorisation or study, reading it in Braille allows me to perform at a much higher level than if I have to listen to it; listening only works for me when it's an easy and superficial text, because I find it very hard to avoid distractions, and if I'm just a little tired, I drop off into a delicious snooze, especially if the reader has a pleasant voice. I've asked a great many of my colleagues about this matter, and all of them who are at least minimally fluent in Braille agree with me.

And by the way, reading with your ears can come in handy when you have a big pile of ironing to do; there's a time and a place for everything!

3 Technology at The Service of The Visually Impaired Readers

3.1 How Can Technology Help Me when I'm Reading?

To a greater or lesser extent, technology is already present in the day to day life of every citizen, including those with impaired vision, and has an influence, not always, and not necessarily a positive one, but a considerable influence nonetheless, on everything we do. I will leave it to the sociologists to assess and analyse this general influence: in this article I will limit myself to analysing where we are and where we want to go with regard to texts and access to texts. And the first thing we need to understand is that this issue cannot be dealt with in isolation from the general context.

These days we make use of technology for all reading associated activities:

- In order to produce reading material
- In order to produce alternative reading mechanisms to replace paper or audio cassettes

- In order to make a radical change to the way we read: browsing, querying...

Bibliographical production, whether in Braille or in print, is inextricably linked to technology, and blind users wishing to make use of the material produced by this technology will also need to evolve and adapt to new ways of reading. In addition to the normal methods involving paper or cassettes they will need to use standalone devices or, better still, PCs, even if this involves making an extra effort to acquire general computer skills and learn how to handle adaptations for blind people or visually impaired users (at user level, naturally, not at expert level; we'll leave that for the producers). Given that all published material is stored on a digital medium, if this medium were available to blind people then logically we would have potential access to everything that is ever published. But the issue is not so simple.

3.2 What Medium Should A Publication Be Stored On So That A Visually Impaired Reader Can Access It?

An analysis of the great variety of digital media around these days – text format, graphics format, Internet file (basically HTML), preprint layout... – is far beyond the scope of this article. The choice of medium is up to the producer of the material, since there are all kinds of manipulation tools capable of converting any input source – keyboard, scanner, voice – into the desired format, depending on various criteria, not the least of which is personal preference.

Let's leave that part of the problem to be solved by the tools which serve as an interface between the computer and the visually impaired person, and let us focus on the range of products that those interfaces allow us to use, bearing in mind that our choice of solution is also conditioned by which interface tool we use, which in turn is dependent on our operating system, while even the computer itself (type, make) can have an influence. In other words, we need be careful not to make sweeping generalisations but rather speak in terms of probabilities. At the moment, and I stress 'at the moment', because of the break-neck speed of development of software and even the very operating systems themselves, we can access information in Microsoft Word, Wordpad, Notepad, PDF, TFL, Daisy, HTML and others.

3.3 What Aids Does A Visually Impaired Person Have Access To?

Depending on a number of factors, such as residual vision, degree of computer literacy, disposable income, training, personal preferences, users will try to read in whatever way

they find easiest or most pleasurable, and there are a number of different kinds of interfaces to choose from:

- Computer installed screen magnifier.
- Computer installed voice synthesized screen reader.
- Computer connected Braille display.
- Braille printer for producing paper books.
- Standalone voice device.
- Standalone Braille device.
- Computer installed voice operated Internet browser.

Each type of interface has its pros and cons which I will not be going into either exhaustively or systematically. I will, however, be mentioning them all briefly with a relevant example, keeping the focus always on reading as my main purpose.

At the risk of stating the obvious, let me say that no one interface is better than another; each reader should be able to use whichever interface is best suited to his or her particular circumstances.

Nowadays the range of available products covers every possible facet of the problem. However, it is clear from the outset that Braille is losing the battle to voice. While users of voice screen readers can, in the main, make use of ordinary technology applied to that purpose, any solution using Braille requires at least some specialized technology, which inevitably pushes up the final cost. Since all, or nearly all, Braille users can also hear, voice based solutions tend to come out on top. If we look just at standalone devices for blind people, voice solutions far outstrip Braille based ones, both in quantity and in price. And there are a hundred talking Braille devices in circulation for every device with a Braille output. However, neither the number of users nor the cost should be the priority factor with regard to the research and marketing of these kinds of aids, or the transcription of books into Braille. Instead we need to create mechanisms, funded by state subsidies, or subsidies from other suitable organisations, such as the ONCE (Spanish National Organisation for the Blind), to counteract this trend and thereby prevent the use of Braille from being limited to those who are both visually impaired and wealthy, circumstances which do not necessarily go hand in hand.

3.4 What Braille Displays Or Printers Are on The Market Nowadays?

Braille displays are devices which can be connected to a computer to enable users to read the text which appears on the screen in Braille. Their size will depend on the number of characters they can represent at any one time (20, 40, 70, 80). Their weight has been steadily coming down and they are not as



Figure 4: Ecoplus 80 Braille Display.

weighty nowadays as when they first came out.

They do not normally have batteries, although there are some on the market which come equipped with them. 70 or 80 character devices could be said to be transportable, though not really portable. Each cell is a separate element within the display. They are built using highly resistant ceramic components which are mainly what makes these devices so expensive.

20 character displays tend to be used on standalone devices such as notebooks, organisers. For computer use the larger models are recommended; these currently tend to have 70 characters rather than 80, because that 12.5% reduction enables manufacturers to bring down the price, weight and size, and for the Windows environment it is considered to be sufficient. In Spain, the supplier of Braille displays is ONCE, which assembles and distributes them exclusively for the Spanish market. The model they are currently supplying is the 80 character Eco Plus shown here in Figure 4 (smaller models were ruled out due to their poor price/quality ratio). They are shortly to bring out the 70 character Satellite display, selling for around 4,500 euros.

The first Braille displays to come on the market were connected to the computer by hardware (i.e. by a card). Nowadays the design has changed and they are now managed by software, and are under the control of the screen reader; in other words, it's the screen reader that controls the device. This means that in order to use Braille you have to begin by operating a screen reader which provides voice options, with the result that the step of 'adding' Braille will often be skipped. It also requires the existence of a driver to enable the screen reader to recognise the display; in other words, users will be limited in their choice of Braille displays to those that their chosen screen reader can recognise.

The ONCE has already distributed among its members, either for purchase (the least common option), or as a workstation adaptation, or as a study station adaptation, some

1,500 screen readers with Jaws software from the company Freedom Scientific <<http://www.freedomscientific.com>>. Some 1,100 Braille displays are supported by this chosen screen reader package.

With regard to printers, ONCE supplies a personal model, the *PortaThiel*, which prints 'interpoint' (doublesided) Braille at 14 characters per second, at a cost of around 1,500 to 2,000 euros, depending on the customer (in this case not exclusively in the Spanish market). Plus a couple of professional models: the *Impacto Texto*, which can print 250 characters per second (i.e. 800 pages an hour) without a graphics connector, and the *Impacto 600* which is made to order and is somewhat slower but does have a graphics connector. For either device the price ranges from between 13,000 and 14,000 euros. There is currently nothing available in the mid-price range, although older models of Thiel printers cover this need.

Something which never ceases to amaze is that, after all the years Windows has dominated the market, drivers for printers under Windows have only become available relatively recently. ONCE's bibliographic production centres are still working under MS-DOS, although they are now finally planning a switch to Windows.

3.5 How Do The New Forms of Reading Benefit A Visually Impaired Person?

Braille books have been, are, and will always be big and beautiful, and so it continues to be a practical impossibility to keep a library of Braille books at home. However, if the storage medium is a CD, how many books could we keep? A whole shedload, if you'll pardon the expression. And if we can read that CD by using device X which will also provide us with a Braille version, we will have discovered the first huge advantage. If, on top of that, some of those CDs contain a dictionary or an encyclopaedia, we will have another incredible advantage: that of putting reference books within the reach of most blind people. This is a substantial change which will benefit a great many groups of people, especially students.

Another fundamental improvement is the possibility of accessing the content of a book wherever you want – at a particular chapter or at the index – and, in general, move around the book with an ease which is simply not possible with an audio cassette or a printed book. In short, thanks to technology we will be able to, and in fact we already can, read more and better. And any effort we need to make to adapt to a more complicated way of managing reading material will be more than repaid.

4 Digital Libraries

4.1 Where Can Digitalized Books Be Found (Including on the Internet)?

I am sure there is no topic in the world about which there is no information or documentation available on the Internet, so I am equally sure that there are books on the Internet. And there are. There are several web pages where books are to be found, responding to different criteria, in different formats, etc. etc., but books nonetheless, and a fair number of them at that. But not only on the Internet. They are to be found in other forms too.

I will tell what I know as a user interested in reading and technology, but before I begin, I would like to make a plea for an exhaustive and organised study of what there is, so we can all benefit from the efforts being made by various groups in several different directions with the aim of creating digital libraries, publicizing their existence, and making a wide ranging and comprehensive bibliographic collection available to blind people everywhere.

I view positively all the efforts made by the ONCE and other institutions who are addressing this task so that we blind people can read, but it is no secret that there is an overwhelming disproportion between the number of books published and the number that are available to blind people, and that there is normally a long wait between wanting to read a book and actually managing to read it, especially if the book has only just been published. Or that there is an enormous lack of dictionaries and encyclopaedias or reference books in general.

4.1.1 A Few References of Spanish Literary Works Available Online

- The Cervantes Virtual Centre (Cervantes Institute) includes the following works in its collection "*Clásicos hispánicos*", <<http://cvc.cervantes.es/obref/clasicos/>>
- Anon: *Historia de Enrique, fi de Oliva*. Critical edition by José Manuel Fradejas Rueda. Text and edition based on the first edition of 1498.
- Gustavo Adolfo Bécquer: *Rimas*. Annotated critical edition by Luis Caparrós Esperante.
- Miguel de Cervantes: *Don Quijote de la Mancha*. Critical edition with commentary by Francisco Rico, published by the Cervantes Institute.
- Lope de Vega: *El perro del hortelano*. Edited by Rosa Navarro Durán.
- John Minsheu: *Diálogos*. Published by the Cervantes Institute under the direction of Jesús Antonio Gil. A bilingual book, originally, which was used to teach Spanish in

Tudor England. The first edition was in 1599.

The Cervantes Virtual Centre has also published online an anthology of texts as recommended reading intended for students of Spanish as a foreign language. The section is called *Lecturas paso a paso* and can be found at <<http://cvc.cervantes.es/aula/readings/>>.

There are other digital libraries in Spanish on the Web, the best known of which is the Miguel de Cervantes Virtual Library, <<http://www.cervantesvirtual.com/>>, with its infant and youth section, <<http://www.cervantesvirtual.com/portal/platero/>>. We should also mention Libros en Red, <<http://librosenred.com/>>, and El Alpeh.com, <<http://www.elalpeh.com/>>.

4.2 Will I Be Able To Read, Legally, Everything I Want to?

An important issue we still need to resolve, at least here in Spain, is the matter of copyright. First we need to set up the necessary legal channels and, at the same time, reach agreements with the publishing houses, and with the authors themselves if need be, to find a solution so that whenever a book is published, it is transmitted by the agreed channel to a digital library accessible to blind people, where the appropriate conversions or adaptations can be made, in order to guarantee both its protection and its accessibility. As I understand it, this is absolutely viable today with the technological resources we already have, although it may not necessarily be a simple task.

4.3 Are There Already Digital Libraries For Visually Impaired People?

Although the degree of implementation varies from country to country, the answer to the question is yes. In 1996, in response to a clear need, the DAISY Consortium <<http://www.daisy.org>> was set up with a very specific purpose: to define an international standard for the production, exchange and use of the new generation of digital talking books.

As a result, the standard known as DAISY, an acronym of Digital Audio based Information System, was created. This standard complies with specifications for textual information and its structure set out in the standards published by the World Wide Web Consortium, <<http://www.w3c.org>>. The consortium is a non-profit organization working with third party companies, which over the years has been developing the tools required for the production and distribution of digital talking books, from workstations and tools for converting old analogical talking books, to the

new playing systems that will be needed in the future.

Within the consortium there are two kinds of members, full members (like ONCE), and associate members. The difference between the two types of members lies basically in the rights to use the software developed through the consortium. For full members there is no limit to the number of licences they can use.

Alongside this software, some countries have also developed related programmes, which, as is the case of the Swedish state library TPB (Library of Talking Books and Braille, <<http://www.tpb.se/english/index.htm>>) or the Japanese JSRPD (Japanese Society for Rehabilitation of Persons with Disabilities, <http://www.jsrpd.jp/index_e.html>), are distributed to consortium members at no cost. These include programmes for playing digital talking books on a computer, such as the Player 2000 from TPB, or for the production of talking books, like the Japanese Sigtuna.

Other countries are developing tools to cover all aspects of talking book production, such as the special editor created by the Danish Library for the Blind, DBB (*Danmarks Blindbibliotek*, <<http://www.dbb.dk/English/>>). In some cases these tools are free and in others you have to pay – it varies from country to country – though it should be noted that the abovementioned programmes are usually in the original language and in some cases in English. One important aspect of this project is the possibility of using voice synthesisers to ‘record’ the books, which is a great technological aid to reducing production costs.

Based on this format, the library Bookshare, in the United States <<http://www.bookshare.org/web/Welcome.html>>, is already up and running and providing a free service for US citizens, while, the Japanese and the Swedes are also already in full production.

In Spain, the ONCE already has more than 2,500 titles prepared. Currently all their recordings are created in this format and before too long we can expect the trial period to be deemed completed, whereupon this type of talking book should be made available to all the organisation’s members.

There are several types of talking book players on the market, such as those produced by the Canadian company Visuaide, <<http://www.visuaide.com/>>, or the Japanese Plextor. The Víctor, from Visuaide, is a desktop reading device which is very user friendly, with large and well separated keys making for easy operation – I see it as the modern version of the traditional cassette player.



Figure 5: Plectalk Reader-Recorder, from Plector.

Plectalk, from Plector, <<http://www.plectalk.com/europe/>>, is a reader-recorder which can be used both as a player and as a creator of DAISY books (figure 5). It has been equipped with more functionalities and it is rather more complicated than the previous one if you want to make use of all its capabilities. It can be connected to and operated via a computer. Braille, however, is the great absentee in this device. We will have to wait.

4.4 Are There Any More Libraries for The Blind?

Our Argentinean colleagues have set up an interesting experiment, which, to the battle cry of “*let’s scan and read, we are all brothers*” have created a library called **Tiflobibros** which has just turned four years old and already has more than 9,000 titles. This library can be found at <<http://www.tiflobibros.com.ar>> (Figure 6). They are doing a magnificent job since, as well as sharing experiences and pooling the expertise of a large number of people, they have created some proprietary software for the protection of books which should not be accessible to everyone. These books are created in a format known as.TFL and require special software to read them. This software is provided free of charge to the library’s readers, and to register as a reader you have to provide documentary proof of your disability, thereby guarding against copyright infringements by unauthorised users. They have already successfully signed an agreement with at least one publishing house. And their effort is all the more laudable given the fact that they are working on a volunteer basis. The books in this library are generated in various formats: Word, MS-DOS, HTML, Braille, Adobe PDF, as well as the special format we mentioned earlier, TFL. They can only be read via a computer so the way they are read will depend on the interface the user has, i.e. Braille, voice, or character enlargement. They currently have 900 readers

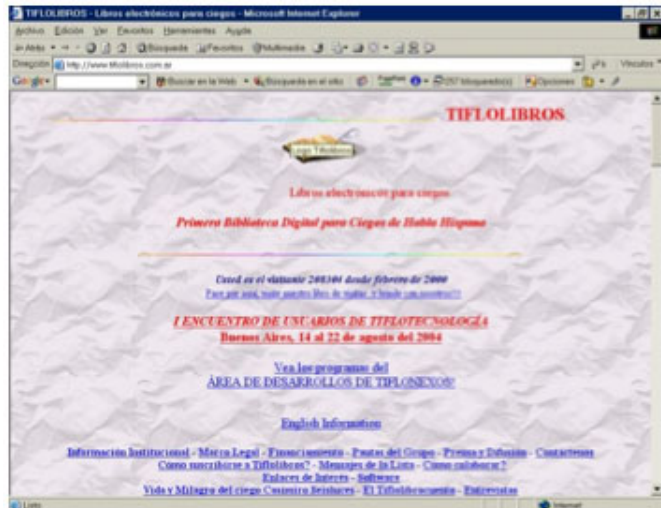


Figure 6: Argentinean Portal Tiflobibros, <<http://www.tiflobibros.com.ar>>.

spread all over the Spanish speaking world as well as in countries where there are students of Spanish.

Last November, in Colombia, ahead of 140 other projects, Tiflobibros won the Betinho Communications Prize recognising people-centred technology initiatives in Latin America and the Caribbean, awarded by the Association for Progressive Communications.

4.5 Are Only We Blind People Interested in Digital Books?

By no means. If that were the case, there wouldn’t already be so much bibliographic material on the Web. However, I would say that this is a culture which is changing, albeit very slowly. While bibliophiles continue to prefer printed books, with their characteristic smell and feel, the use of digital formats for dictionaries, encyclopaedias and reference books in general is becoming ever more commonplace.

At this point in time, the only digital book-sellers that I have ever heard of has unfortunately had to close down. The publishing house RD Textos was created with the dual purpose of creating a virtual bookshop, i.e. as a business, and providing a service to blind or visually impaired people by selling books at modest prices in both HTML and in Braille. This publishing house, set up with every legal angle covered, including copyright, failed due to a lack of turnover. The bibliographic collections that they had prepared, which are no longer under copyright, have been donated to the Manuel Caragol Foundation, <<http://www.funacaragol.org/>>, which has published them on the Web, from where they can now be downloaded free of charge. I am really sorry

that they failed because I believe they were doing a good job.

4.6 Are There Any New Projects Underway (‘Hybrid’ Books)?

Some time ago now, a new idea emerged from Hungary which is now being developed by various projects. The idea is to implement a system using what we might call ‘hybrid’ or mixed technology in such a way that any book created by that technology could be read either by voice or by Braille. If this project comes to fruition, we would no longer have to choose between voice and Braille when adapting a book for blind readers.

These initiatives originally received funding from the European Copernicus project. Later, in various stages, the country itself financed the development of a special player and the production of several books. Later still, from France, the project Culture 2000 funded the development of a tactile component, the 3T-book, <<http://www.Brailenet.org/Tbook/traduc.htm>>. Now, once again with local funding, they are currently working on adapting the browser to an electronic organizer type device. Among the benefits expected from this hybrid technology are:

- The user can make searches for sequences recorded in human voice.
- The user can read texts recorded in human voice on a Braille display.
- It is already prepared for use with various browsers.
- Tools are already available for creating books in this format in Hungarian, French and Italian.
- Blind people can use digital book creation tools in this format.

There is already a prototype of the reader with a Braille keyboard, CD-ROM, and several CDs in the three available languages (French, Italian and Hungarian). In my opinion this is a very interesting project, because being able to decide on the fly how you want to read will make it possible to get the best out of both worlds. Why force a decision if it can be avoided?

5 Conclusion: Braille as Pleasure And Culture

Can Braille be a source of enjoyment? I think the answer is clear throughout this article, but before I close, let me repeat that I wholeheartedly support Braille as provider of pleasure, leisure and enjoyment; reading is one of the treasures which I would not give up for the world. To touch a book, feel it under my fingers, caress it and immerse myself in all the wonderful literature that has been written.

We blind people also deserve to savour the pleasure of reading José Hierro or José Saramago but, without Braille, it would be like looking at faded, discoloured painting. Now, with the aid of technology, the aim of reading any book right away should become true for blind people.

In the pursuit of standardisation, for the sake of the blind, let's read.

Translation by Steve Turpin

Information Technology in Today's Organizations

Is The IT Productivity Paradox Resolved?

Kyriakos E. Georgiou

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This article addresses the issue of the Information Technology (IT) Productivity Paradox. The paradox was formed as a result of the apparent failure of substantial investments in IT to produce the desired results. The main school of thought in the USA uses econometric studies to measure the effect of IT on the performance of firms, sectors of the economy and the economy as a whole. This line of work comes under criticism from the European (read British) school of thought that consider it as too simplistic and one dimensional. Most recent research work suggest a highly positive relationship between investment in IT and organizational performance. The main emphasis of the research these days is to determine the business value of IT.

Keywords: Business Value of IT, Economics, Information Technology, Information Technology Paradox, Productivity, Production Functions.

Introduction

The issue of the effects, if any, that Information Technology (IT) has on the productivity of organisations has been one of the most critical issues in the IT field [Blake, 1994], [Brancheau. et. al, 1996]. The topic has extended beyond the boundaries of academia and it has captured the attention of the press [Bowen, W. 1986, Magnet 1994], Business Week 1993], the mass electronic media as well as the policy makers all over the globe. The term "information technology paradox" has entered the lexicons and everyday conversations. Organisations, researchers, policy makers and the press have begun to question the benefits for organisations from their substantial investments in IT.

Productivity

Productivity is a measure of performance and the only measure of competitiveness. It can be defined as the relationship between the inputs applied and the outputs that result, that is to say, the ratio of outputs to inputs. Outputs can be any combination of goods, products, or

services whilst inputs can be human or material resources transformed in the process. Productivity is directly related to efficiency and effectiveness.

Efficiency refers to the optimal utilization of existing resources. In economics efficiency is the ratio of what an organization actually produces and what it could optimally produce with its existing resources, knowledge, and ability. Effectiveness refers at a minimum with the achievement of the goals of the Organization. A more proper definition attributed to Peter F. Drucker (1995) is the ability to expand the limits of the organization in terms of the opportunities to produce revenues, to create markets and to change the economic characteristics of existing products and markets. In the long term effectiveness is much more important for sustained productivity.

Traditional measures of productivity which has its roots in industrial engineering and agriculture do not address properly intangible factors such as product and service quality, variety and reliability and customer satisfaction. These intangible factors are key elements of competitive success in the strategy and marketing literature.

The Theoretical Background

Virtually all the studies before the late 1980's do not show a significant positive impact of IT on the productivity of organisations. This phenomenon led Dr. Robert Solow of MIT back in 1987 to comment that computers can be seen "everywhere except in the productivity statistics" (Solow). More recently there was a shift in this thinking since most recent studies show a positive relationship between investment in IT and the productivity of the firm.

Researchers in the field among others, include Erik Brynjolfsson of MIT and his associates at the MIT Centre of e-Business (<<http://ebusiness.mit.edu/>>) and Lorin Hitt of the University of Pennsylvania, Wharton School of Business, associated with the MIT team. In New York Yanis Bakos of the University of New York Stern School of Business

and Frank Lichtenberg of Columbia University. In California Kenneth L. Kraemer, Vijay Gurbaxani, Nigel Melville and Ronald V. Ramirez associated with the Centre for Research on Information Technology and Organizations (CRITO) at the University of California at Irvine, <<http://www.crito.uci.edu/2/>>. These researchers have conducted extensive research, utilizing econometric analysis of multifactor productivity, in the USA. This type of work, though, has come under some criticism from other researchers in the field most of them in the UK [Dan Remenyi & Frank Bannister, 1999], [L. P. Willcocks and S. Lester, 1996, 1997] and [Jean Noel Ezingard 1998].

Recent research has shown that longitudinal three-to-five year firm level studies demonstrate better results than single year studies, or macroeconomic studies of sectors of the economy or the whole economy [Hitt, 1996], [Mooney 1996], [Shu 1998], [Brynjolfsson, E. and Hitt, L.M.1995a], [Brynjolfsson, E. and Hitt, L.M.,1995b], [Brynjolfsson, E. and Hitt, L.M.,1996]. It appears that there are at least four reasons for the positive results of more recent studies:

- (a) The sophistication of the research has evolved substantially;
- (b) IT has matured and is now a much more powerful and useful set of tools;

Kyriakos E. Georgiou is one of the editors of *Pliroforiki*, the journal of the Cyprus Computer Society (CCS). He is a Senior Manager for Professional Services for NetU Consultants. He occasionally teaches management courses in local colleges. He has a Bachelors degree in Mechanical Engineering and a MBA, both from the University of Houston, Houston, Texas, USA. The efficient and effective use of IT in organizations is one of his main professional and academic interests. <Kyriakosg@netu.com.cy>

- (c) Organisations as a whole have been more successful in using IT in the context of achieving business objectives; and
- (d) In most cases successful IT implementation is coupled with organizational change. Organizational change programs include employee participation programs, Total Quality Programs and Process Reengineering.

The first studies on IT productivity originated back in the 1970's. However there is a general agreement among the research community that those early years are not really representative. In the 1980's and early 1990's when the term the "IT productivity paradox" was coined by Baily and Gordon (1988) most of the studies showed negative correlation between capital expenditures on IT and measured productivity gains. Over the years since then, the balance has shifted towards more positive results.

Most researchers, though, it seems that they have a more or less ideological position on either side of the argument and most of their work is in support of this a priori 'ideological' position. As Bakos (1995), states "(we) put to rest once and for all the old idea that computers are not productive". Quinn and Baily (1994) add the point that "(if) managers did not think IT improved performance, they would not have continued to invest so heavily".

It is fair to say that the empirical results that most academic researchers, in the USA, reach these days show positive returns on IT investment. The work of Brynjolfsson and Hitt (1993; 1994; 1996) and Lichtenberg (1995) among others are along these lines. On the other hand the work of Paul Strassman (1985; 1990; 1997) and Stephen Roach (1989a; 1989b; 1996) point in the opposite direction.

There are two fundamental research questions:

1. Does IT offer the potential to enhance productivity and firm performance?
2. If IT provides potential benefits how do organizations manage and use IT to enhance productivity and create value?

In general the field is influenced by research carried out in the USA and not enough attention is paid to research carried out in the United Kingdom. Established practitioners in the field there include Professors Arthur Money, Dan Remenyi and Twite, A. [Remenyi et al. 1993], Jean Noel Ezingard (1998) associated with Henley College but also L.P. Willcocks and S. Lester (1996, 1997) associated with Oxford just to name a few.

Most British researchers are critical of the economic approach that American researchers prefer. Brynjolfsson (1993) for instance in order to reinforce the point that the economic

production theory provides an excellent method for measuring the efficient application he writes "*the bottom line of any technology is not how it changes work, but whether it increases productivity.*" Remenyi and Bannister (1999) on the other hand quoting a similar point from the same article suggest that "*This narrow perspective is (perhaps deliberately) limited in its understanding of the nature of IT value*". Along the same lines Ezingard (1998) suggests that there is now a recognition that evaluation should be concerned with more than simple 'efficiency' metrics. Academic techniques and constructs have yet to be widely adopted by practitioners. The emphasis in research should be placed on the impact that IT has on the entire organisation.

In any case the following statements are practically universally accepted:

1. The findings of IT productivity impacts research are inconclusive. This is a major theme of all the research in the field and it is precisely the issue that gave rise to the term "Productivity Paradox".
2. Firm level research offers more meaningful results in terms of accuracy and reliability as opposed to economy, industry and sector levels research. The reason for this is that beyond the firm level the data becomes difficult to use because it contains items that cancel each other out.
3. Longitudinal designs are more appropriate rather than single year or cross-sectional ones. Longitudinal designs are more in line with the process nature of the IT implementation.
4. More recent research is more probable to show a positive correlation between investment in IT and business performance.

The Econometric Model

The development of reliable, consistent and meaningful techniques for assessing the relationship between investments in Information Technology (IT) and firm performance is a very crucial issue since it lies in the centre of the research in this field. The emphasis of the literature review is on *ex post* measurement of the impacts of IT investments on firm performance rather than *ex ante* evaluation of the potential impact of proposed IT systems.

The role of firms in the economy is to produce goods and services called in generic terms "outputs of production", utilising a number of inputs that can be grouped into five groups namely capital (K), labour (L), energy (E), materials (M) and purchased services (S). Using different quantities of each production input that best suit its needs a firm tries to compete in the market and produce the most optimum product mix. In this presentation one form of production input can be replaced

by another. The most common substitution is capital and outsourcing services for Labour. In a more formal presentation as a production function (F) these relations can be presented as:

$$Y = F (K, L, E, M, S) (1)$$

In studies of the productivity of IT the two most important independent variables are Capital (K) and Labour (L) that have two components each. One component is associated with the use of IT identified by (1) and the other refers to non IT related forms of capital or labour identified by (0).

I believe that an extension of the theory would be to examine how purchased services (outsourced services) affect the productivity of firms. This is important since outsourcing has become an integral part of the application of IT. Jablonski (1995) uses a production function that includes capital, labour and intermediate purchases to measure multifactor productivity in the U.S. textiles sector. Also Brynjolfsson and Hitt (2000) in a MIT Working Paper are extending their previous work and include Research and Development (R&D) as the third independent variable. On the other hand energy (E) and Materials (M) are of lesser significance especially when it comes to firms in the service sector of the economy. In this case the production function should include purchased services (S) and it should look like this:

$$Y = F (K_0, K_1, L_0, L_1, S_0, S_1) (2)$$

The Cobb-Douglas model is used nearly exclusively in previous IT Business Value research at the firm level [Brynjolfsson and Hitt 1996], [Gurbaxani, et al. 1998], [Lichtenberg 1995]. Empirical research has proved that this model is a reasonable model for estimating the returns to IT investment. A basic Cobb-Douglas production function has the following form:

$$Y = A K_0^{\beta_1} K_1^{\beta_2} L_0^{\beta_3} L_1^{\beta_4} S_0^{\beta_5} S_1^{\beta_6} (3)$$

The term A is the technical efficiency of a or Multifactor Productivity (MFP). MFP signifies contribution to output that is not accounted for by inputs to production. By taking logs the Cobb-Douglas model would take the form:

$$\log(Y) = \alpha + \beta_1 \log K_0 + \beta_2 \log K_1 + \beta_3 \log L_0 + \beta_4 \log L_1 + \beta_5 \log S_0 + \beta_6 \log S_1 (4)$$

In more complete form equation (4) has three control variables that account for time (t), industry (j) and the specific firm (i). By introducing these variables the production function takes the form:

$$\log(Y_{tij}) = \alpha_{tij} + \beta_1 \log K_{0,tij} + \beta_2 \log K_{1,tij} + \beta_3 \log L_{0,tij} + \beta_4 \log L_{1,tij} + \beta_5 \log S_{0,tij} + \beta_6 \log S_{1,tij} (5)$$

The coefficients (β_i) represent the output elasticity of input i and their estimation repre-

sents the contribution of IT investment to firm output.

The Cobb-Douglas production functions has two general assumptions:

1. The elasticity of substitution is assumed to be constant and unitary. This implies that an n percent change in the marginal rate of technical substitution will yield a n percent change in input mix.
2. It exhibits constant returns to scale that is if all inputs increase by a factor n then output increases by factor n.

$$\text{And } \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 = 1 \Rightarrow \sum \beta_i = 1 \quad (6)$$

Reading through the literature review a reader can truly appreciate the methodological and theoretical issues that form the core of the research. This type of research is carried out using essentially secondary data and the researcher has to make a lot of assumptions in order to fit the data into the model. These assumptions and the way they operationalise their variables at the end of the day can have a significant effect on the result of the research. Also the sample size can be problematic as many of the studies are based on a limited sample size of even less than 50 observations. I believe that primary data from a respectable sample size of at least 100 organisations over a three to five year period interval within the context of a given economy will probably provide a better set of data for running this type of analysis.

Both Brynjolfsson-Hitt and Lichtenberg in their respective work are using sales revenues as their output variable of the production function. Other researchers such as Stewart (1991), Drucker (1995) and Strassmann (1997) and Ramirez (2003) suggest that EVA (Economic Value Added) is a more appropriate and objective measure of an organisation's productivity and performance and they also suggest that it is used as the output or dependent variable. EVA is defined as the return on capital minus the Weighted Average Cost of Capital (WACC) multiplied by the capital outstanding at the beginning of the year (Steward, 1991).

The Hypotheses

The core research question is the relationship between investments in IT and firm level productivity. Based on the model developed in the previous section a number of hypotheses can be formulated to provide the desired answers. The hypotheses evolve around the marginal products, or the related parameter of the output elasticity of the independent variables.

By taking derivatives of equation (5) the output elasticity of input X becomes

$$\beta_i = d \log(Y) / d \log X = (dY / dX) (X/Y) = MP (X/Y)$$

Where MP is the marginal product of variable X.

There are a number of hypotheses that one can draw based on these formulations but for the purpose of this exercise we concentrate on those that have proven more powerful and interesting [Money, 1996], [Lichtenberg 1995], [Brynjolfsson and Hitt, 1993]

Hypothesis 1. The marginal product of IT capital (K_1) is positive.

More formally we test the hypothesis

$$H_0 : \beta_2 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_2 > 0$$

Hypothesis 2. The marginal product of IT capital (K_1) is significantly higher than the marginal product of non-IT capital (K_0) relative to their rental price.

$$MP_1 / MP_0 \leq R_1 / R_0$$

More formally we test the hypothesis

$$H_0 : \beta_2 - (R_1 K_1 / R_0 K_0) \beta_1 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_2 - (R_1 K_1 / R_0 K_0) \beta_1 > 0$$

Hypothesis 3. The marginal product of IT labour (L_1) is positive.

More formally we test the hypothesis

$$H_0 : \beta_4 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_4 > 0$$

Hypothesis 4. The marginal product of IT Labour (L_1) is significantly higher than the marginal product of non-IT labour (L_0) relative to their respective wage rates.

More formally we test the hypothesis

$$H_0 : \beta_4 - (W_1 L_1 / W_0 L_0) \beta_3 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_4 - (W_1 L_1 / W_0 L_0) \beta_3 > 0$$

Hypothesis 5. The marginal product of IT Services (S_1) is positive.

More formally we test the hypothesis

$$H_0 : \beta_6 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_6 > 0$$

Hypothesis 6. The marginal product of IT Services (S_1) is significantly higher than the marginal product of non-IT Services (S_0) relative to their rental price.

More formally we test the hypothesis

$$H_0 : \beta_6 - (R_1 S_1 / R_0 S_0) \beta_5 \leq 0$$

Against the alternative hypothesis

$$H_1 : \beta_6 - (R_1 S_1 / R_0 S_0) \beta_5 > 0$$

Conclusion

Like in any research the application of production theory to firm level studies has certain strengths and potential shortcomings, mainly the linearity of the function. Although the method is quite robust, reliable and established the search for the perfect productivity measure is still an elusive target, especially in a relatively new field such as IT. Intangible attributes such as service and product quality are hard to quantify and measure and there is always the argument that, unlike work in a production environment, measuring productivity in a knowledge work environment is not appropriate. All these factors add to the complexity of the issue but do not subtract from its importance.

The econometric approach is one of a "black box" where the researcher knows very little of what actually goes on within the "black box", that is, the firms in question. In the next instalment of the article we are going to explore some of the issues, strategic and behavioural, that take place within the "black box" and explore the business value of IT.

References

- [M. N. Baily and R. J. Gordon, 1988]
 "The Productivity Slowdown, Measurement Issues and the Explosion of Computer Power", The Brookings Institution, Brookings Papers on Economic Activity: pp 347-431.
- [J. Y. Bakos, 1995]
 "Are Computers Boosting Computers", Computerworld, March 27:128-130.
- [Ives Blake, 1994]
 "Editors Comments: Probing the Productivity Paradox", MIS Quarterly 18(2).
- [W. Bowen, 1986]
 "The Puny Payoff From Office Computers", Fortune, May 26.
- [J. C. Brancheau, B. D. Janz, J. C. Wetherbe, 1996]
 "Key Issues Information Systems Management: 1994-95 SIM Delphi Results", MIS Quarterly, June: 225-242.
- [E. Brynjolfsson and L. M. Hitt, 1995]
 "Productivity without Profit: three Measures of Information Technology's Value", 15th International Conference on Information Systems.
- [E. Brynjolfsson and L. M. Hitt, 1995]
 "Information Technology as a Factor of Production: The Role Differences among Firms", Economics of Innovation and New Technology 3(4): 183-200.
- [E. Brynjolfsson and L. M. Hitt, 1996]
 "Paradox Lost? Firm Level Evidence on the Returns to Information Technology Spending", Management Science 42(4): 541-558.
- [E. Brynjolfsson and L. M. Hitt, 2000]
 "Computing Productivity: Firm-Level Evidence", MIT Working Paper.

- [Business Week 1993]
“The Technology Payoff: special report”, Business Week, June 14 1993: 56–79.
- [Peter F. Drucker, 1995]
“The Information Executives Truly Need”, Harvard Business Review 73(5): 54–62.
- [J. N. Ezingard, 1998]
“Towards Performance Measurement Processes for Manufacturing Information Systems”, 5th European Conference on the evaluation of Information Technology, Reading U.K.
- [Lorin M. Hitt, 1996]
“Economic Analysis of Information Technology and Organization”, Dissertation, Massachusetts Institute of Technology.
- [V. Gurbaxani, N. Melville, and K. Kraemer 1998]
“Disaggregating the Return on Investment to IT Capital”, ICIS Proceedings 1998.
- [M. Jablonski 1995]
“Multifactor productivity: cotton and synthetic broadwoven fabrics”, Monthly Labour Review, July 1995: 29–38.
- [F. R. Lichtemberg, 1995]
“The Output Contributions of Computer Equipment and Personal: A Firm- Level Analysis”, Economics of Innovation and New Technology, 3 201–217.
- [Myron Magnet, 1994]
“The Productivity Payoff Arrives”, Fortune, June 27: 79–84
- [John G. Mooney, 1996]
“The Productivity and Business Value of Information Technology Economic and Organizational Analysis”, Dissertation, University of California, Irvine.
- [J. B. Quinn and M. N. Baily, 1994]
“Information Technology Increasing Productivity In Services”, Academy of Management Executive, 8,3: 28–48
- [Ronald Vincent Ramirez, 2003]
“The Influence of Information Technology and Organizational Improvement Efforts of the Performance of Firms”, PhD Dissertation, University of California at Irvine.
- [Dan Remenyi, Frank Bannister, 1999]
“In Defence of Instinct: Value and IT Investment Decisions”, Henley Working Paper HWP 9914.
- [D, S. J. Remenyi, A. Money, and A. Twite, 1993]
A Guide to Measuring and Managing IT Benefits, 2nd Edition, NCC Blackwell Oxford England.
- [Dan Remenyi, Michael Sherwood-Smith, and Terry White, 1997]
Achieving Maximum Value from Information Systems: A Process Approach, John Wiley and Sons Ltd. West Sussex England.
- [Stephen S. Roach, 1989a]
“Pitfall of the ‘New’ Assembly Line: Can Services Learn From Manufacturing?”, Morgan Stanley Special Economic Study, New York.
- [Stephen S. Roach, 1989b]
“America’s White Collar Productivity Dilemma”, Manufacturing Engineering, (August): 104.
- [Stephen S. Roach, 1996]
“The Hollow Ring Of The Productivity Revival”, Harvard Business Review 74(6): 81–89.
- [Wesley Szu-Way Shu, 1998]
“From Different Angles to Solve the Puzzle: Macro-Economic and Micro-Economic Analyses of Information Technology Productivity”, Dissertation, The University of Arizona.
- [Robert Solow, 1987]
“We’d Better Watch Out” New York Times Book Review, 36.
- [Ill Stewart, G. Bennett 1991]
The Quest for Value, Harper Collins Publisher. New York
- [Paul A. Strassmann, 1985]
Information Payoff: The Transformation of Work in the Electronic Age. Free Press, New York, NY.
- [P. A. Strassmann, 1990]
The Business Value of Computers. The Information Economics Press, New Canaan, Connecticut.
- [P. A. Strassmann, 1997]
The Squandered Computer: Evaluating the Business Alignment of Information Technologies, Information Economics Press, New Canaan, Connecticut.
- [P. A. Strassmann, 2004]
“Defining and Measuring Information Productivity” Information Economics Press, New Canaan, Connecticut.
- [L. P. Willcocks and S. Lester 1996]
“Beyond the IT Productivity Paradox”, European Management Journal 14(3): 279–290.
- [L. P. Willcocks and S. Lester 1997]
“In search of Information Technology productivity: Assessment issues”, Journal of The Operational Research Society 48(11): 1082–1094.