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IT for Sustainable Growth

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Abstract

This paper addresses the changing nature of markets in an IT-rich and Internet connected world. Through a combination of case studies, theoretical analysis and parallels between issues in developed and emerging worlds, it explores whether technology can help create economic futures that are economically, socially and environmentally sustainable for the emergent economies and also offer fresh directions for the culturally homogenised and resource wasteful west. The paper suggests that IT radically changes the 'ground rules' compared with the periods of intense development in western countries in the 19th and 20th centuries. In particular, IT opens the way for less centralised growth, where global communications enable local collaboration, and those at the bottom of the economic pyramid can have presence on the world stage. However, realising the potential of IT to aid sustainability may require strategic efforts to create suitable information and economic infrastructures.

Keywords: Sustainable development, information technology, diversity density.

INTRODUCTION AND OVERVIEW

Two centuries of industrial growth in western economies has been at a price: the erosion of local culture and potential global disaster. Furthermore, the slow 'trickle down' of wealth to those most in need has been at best slow, and in recent years a reversing trend. Emergent economies appear destined to follow the same path towards social and environmental collapse. Can technology, which in some cases has brought us to this point, also help create economic futures that are economically, socially and environmentally sustainable?

In this paper we examine some of the ways in which IT has the potential to enable more sustainable paths of development. We consider a way in which IT can enable better use of resources and can help preserve local culture. Most radically we consider the way IT fundamentally transforms the nature of economic relationships and the information role of money.

This paper has two main sources. The first is the experiences of one of the authors during the dot.com explosion (and subsequent crash) during 1998–2000; the need to understand the nature of Internet products led to analysis of the radical potential for Internet products to transform daily life and also the realisation that information technology was already giving rise to a more fundamental transformation of the nature of money itself.

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The other source has been the meetings of the UK India Network on Interactive Technologies, which has focused on the need for IT to contribute to development that is economically, environmentally, and socially sustainable.

The path of development that has led to the current position in most western 'developed' countries has clearly been economically successful, but often at the cost of social cohesion and global environment. It sometimes seems that the development of the other two thirds of the world will inevitably follow the same, ultimately catastrophic, path. Is this inevitable, or are there alternatives?

The paper examines the myth of a single linear path of development that still permeates much of our thinking and suggests that new technology can offer alternative paths to similar development goals which are more *environmentally sustainable*. The paper further focuses on *economic sustainability* and discusses the radical way in which digital technology has changed the nature of money, bypassing money's role as purveyor of information on needs and provision. This is transforming the relationship between producer and consumer and in particular enabling local connectivity through global networks. The study then looks at some of the parallels between the human needs in the UK and India and some of the lessons that can be learnt from past mistakes and present successes and in particular the way network connectivity can open global markets and address issues of *social and cultural sustainability*. Finally the study asks whether the potential of IT to help address sustainable development will happen as a natural result of economic forces.

THE CONTEXT FOR SUSTAINABLE IT – DEVELOPMENT TRAJECTORIES

Linear Development: Politics and Presumption

A common understanding of the development of countries is a linear progression, with different countries or parts of the world 'further along' than others. This 'inevitable' path of history is a common theme of the politics of both left and right. For Marx the rise of the proletariat, conflict and revolution were not goals to strive for, but the inevitable course of history. Although expressing very different political agendas, in his speech to the World Trade Organization on the 50th anniversary of the multilateral trading system, Bill Clinton said, '*Globalization is not a policy choice — it is a fact*.' (Clinton 1998); and the 'Freedom Agenda' of Bush's term was often couched in the language of inevitability:

'*This* [democracy] *is just the inevitable course of humankind because all humans want to be free*.' (Bush 2005).

The idea of linear development whether political, social or technological is not just a way of analysing the world, but impacts individual actions and national policy. It can be a *source of comfort* to the disadvantaged, as change will come eventually; the idea that at least our children or grandchildren will see a bright future has been a recurrent theme in movements across the world. It can be an *excuse for complacency*, as a country may be regarded as not yet ready for some 'stage' of development. This was effectively the Leninist view of China, which was regarded as unsuitable for communist revolution as it did not have a developed urban industrial proletariat. Perhaps most disturbing, it can be an *argument for coercion*, accelerating 'inevitable' development in the knowledge that any pain caused is simply easing a difficult process that will happen anyway.

Of this last, there are numerous examples on the left and right of politics. Marx dissuaded Engels (the son of a factory owner) from emulating the liberal practices of reformers such as Robert Owen as improvement to the working conditions of the industrial proletariat would delay the (inevitable) path to revolution and greater emancipation. In recent years, radical military interventions are often portrayed as being of benefit to the attacked nations as they are being helped along their way.

Despite its prevalence, this view is often challenged on political or philosophical grounds. Doreen Massey, a geographer, regards these linear models, which of course place western democracies 'further along' the line, as at best paternalistic and at worst fundamentally colonial (Massey 2005). She emphasises the radically different cultural viewpoints, citing especially (given her geographic roots), the fundamentally different conceptions of space embodied in Cortés' maps of the Aztec city of Tenochtitlán with those of the Aztecs themselves. After Bush's second inaugural speech, Anatol Lieven parodied the President's position on the inevitability of (American) democracy quoting the (fictional) US General in Kubrick's *Full Metal Jacket*, '*inside every gook there is an American waiting to get out*' (Lieven 2005).

These alternative views allow us to view development as more contingent, not just temporally, in the rate of change, but in terms of overall direction and trajectory. Development is seen, not as a high road with different stops along the way, but more as divergent paths depending on

geographic, cultural and historical factors. Of course, this non-linear view can itself be used positively as an opportunity to resist the culturally degenerative role of the media, arresting the apparently inevitable path to sneakers, soap opera and soda pop; or negatively to restrict freedom of expression and flow of information in the name of cultural diversity. Indeed, the same action may often be viewed in either light.

Linear Development and Sustainability

Whether or not it is socially or politically necessary or desirable, simple linear development is unsustainable. We all know the figures, with less than 5% of the world's population in the USA accounting for more than 20% of global carbon emissions, and the UK's use of energy per capita around 10 times that of India (United Nations 2007). The world cannot afford everyone to 'catch up' if this means achieving the same level of profligacy and often this translates into a sense that parts of the world with rapidly growing economies, particularly India and China, are being asked to put the brakes on development and accept lower standards for the sake of global survival. In the shorter term, competition for resources, in particular water, partly induced by climate change and partly by increased industrialisation and consumption, are expected to lead to intra-national and international conflict.

Yet, whatever the political views, there is clearly some truth in the linear model, whether 'inevitable' or just because it is what is happening. The abject poverty that persists in the 21st century is ethically and politically untenable and some level of economic and educational development is almost universally regarded as desirable even if the form it takes is more open to debate. The challenge we face is whether this development can be achieved without destroying local culture and global environment.

Technological Change

Of course, the myth of total linear development does not bear close scrutiny; even apparently similar developments often differ dramatically in detail. Disease control is a prime instance of this.

In most developed countries the most important factors in the reduction of endemic disease have been social and economic; the iconic example was John Snow's identification of the water born vector for cholera in 19c London (Snow 1855). Until recent concerns about obesity and other diseases of 'affluence' (although still largely affecting the poor), progressive improvements in public health have been associated most crucially with improvements in living conditions: sanitation, housing, diet.

Pharmaceutical medicine has of course been crucial in dealing with many diseases, but overall it has been a secondary factor.

In contrast, in many developing countries drug-based treatment, where available, has been a driving aspect of remedial healthcare throughout the 20th century. Of course, this itself has not been without problems, both acting as a palliative and shifting focus away from underlying poverty, and also being one of the causes (through reduced mortality) of population growth. Few but the most hardened Malthusian would wish away the medical advances; the tragedy is that these were not accompanied by wider social development.

The health exemplar serves to warn us that apparently similar outcomes may have very different causes and implications, so that simplistic development models will be misleading. It also suggests that similar goals or end-states can be achieved by different means. In the case of healthcare, neglect of underlying poverty whilst treating the symptom of mortality has proved environmentally problematic. However, by understanding these broader issues, more sustainable futures may be possible in other areas through alternative technological trajectories, for example, 21st century power generation and industrial production need not be accompanied by the same pollution and carbon emissions as that of the 19th and early 20th century.

The Role of IT

The path of IT use in developed countries does not auger well for sustainability. Environmentally, built-in technological obsolescence leads to increasing amounts of waste, with electronic goods accounting for an estimated 70% of heavy metals in US landfill (svtc.org 2004). However, this need not be the case, the miniaturisation and commoditisation of microprocessors and mobile devices allows the potential for smart applications and appliances that are more sustainable.

As an example, Firefly digital lighting technology developed at Lancaster places a tiny microprocessor behind individual LEDs (Finney & Dix 2007, Chandler et al., 2009). This at first seems technological overkill, and indeed was developed focused on creating highly flexible and innovative display lighting, not on issues of sustainability. However, the use of a microprocessor means that lighting can be controlled very precisely, reducing energy use, and instead of requiring large amounts of wiring, controllable displays can be created using a single two-core power connection, hence reducing copper use.

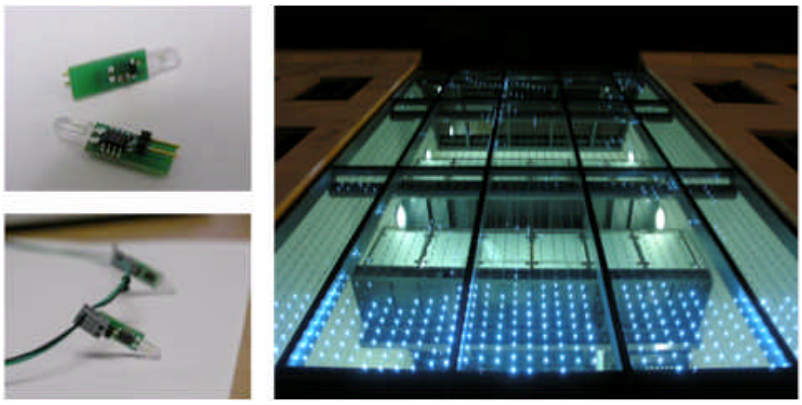


Figure 1: Firefly units

We can see similar stories in other areas where smart technologies are being used to improve the efficiency. For example, IBM uses active sensor technology combined with a very flexible middleware to allow very fine grain monitoring of industrial processes and utilities (mqtt.org 2009). In the home, smart appliances can use information provided through the Internet to turn on only during periods of low demand (Anslow 2009).

In countries with fully developed infrastructure, these technologies have to be retrofitted in ways that are compatible with the existing infrastructure and are therefore often sub-optimal. For example, the electricity supply industry is predicated upon adjusting output to meet a varying demand, rather than tuning demand (through smart appliances) to make the best use of supply, especially with potentially variable and hard to control energy production from renewable sources such as wind-power.

In contrast, countries where infrastructure is still being developed are in the position to leapfrog the developed world and create smarter underlying infrastructures from ground up with the potential for both economic and environmental benefits. This has already been happening with industrial production. Hart (1997) cites the case of BASF; when constructing new plants in the emerging economies, they have collocated different parts of the process allowing much more efficient reuse of waste materials from one part to another.

INFORMATION TRANSFORMING ECONOMICS

Economic Context

The context of development now is very different from those of the 19th and 20th centuries. Whilst industrial development of Western nations took place in the context of apparently unlimited raw materials and a large pool of

cheap overseas labour, emerging economies face rising raw materials costs and are seeking to alleviate the very poverty and global inequality that made Western development possible. In terms of technology and science, Western development has always been playing 'catch up' as technology constantly finds new ways to do the same things more efficiently, and even, recently, more sustainably. In contrast, nations currently developing economically and industrially have the opportunity to avoid problems of the past.

Whereas coal was the driver of 19th century industry and oil that of the 20th century, for the 21st century it is silicon: power is now measured in terabits not megawatts. As well as augmenting mechanical production and enabling mass communication, IT is also transforming the very nature of money on which market economies have relied since the Renaissance.

Money has a dual role. On the one hand it is a medium of *exchange of value*, the most obvious role: the abstract unit of the euro, rupee or pound allows exchanges between those who do not have one-to-one match of needs, and furthermore allows non-local transactions. However, money is also a means of *exchange of information*: paying money for a product implicitly says that the product is needed and the amount paid says how much it is needed.

The 'hidden hand' of economics, on which market economies rely, is based on this second role, the exchange of information. When customers pay money in a shop for bread; this money effectively embodies the information about their individual needs. As shopkeepers order more bread from their suppliers, the needs of the overall area are conveyed. Similarly as the farmer sells grain to merchants and they sell to bakers, this passes on information about the quantity and location of supplies. All of this happens without computers, nor even any centralised ledgers or paperwork.

Both of these roles of money, *value exchange* and *information exchange*, have been changing due to information technology.

For many years the value role of money has been carried forward more through the symbolic idea of units of currency than physical coinage: bank balances, cheques and money transfers, rather than stamped metal. This accelerated with the progressive abolishment of gold standards in the 20th century, and is now almost purely informational with electronic funds transfers, and credit cards. This is possible because the value role of money depends on its *indistinguishability*, it does not matter which money you have, and so a simple notional figure, the number on your balance enquiry, is sufficient. While the physical material of money has changed, the essential value role is still largely intact.

Note that the exchange value of money is explicit in all standard treatments of economics going back many years, for example, Benham

(1955, pp.421-425) discusses various roles of money, but reduces all to that of money as *measure of value*. The information role of money is also *implicitly* present in the discussions of the natural optimisation of markets, but is not explicitly described. Even in recent discussions (for example, Jensen (2007), discussed later) the core informational issue is seen as merely the need to have information about the value of money, to enable a 'perfect' market. There are exceptions, for example, at a macro-economic level, Coenen et al. (2005) use money demand as proxy information about aggregate output in the European Union.

However, it is this, less well-understood, informational role of money that is transforming most radically in the face of IT.

The Informational Role of Money and Diversity Density

While money transfers information, it does so inefficiently from the point of view of information. Returning to the bread example, if one customer pays for bread the shopkeeper knows that that particular customer wants it. However, when the shopkeeper pays the supplier for 100 loaves of bread, the information about precisely who wanted the bread has been lost. Similarly, when the miller pays the merchant for flour, the knowledge of precisely which farmer produced it is lost. Both individual consumers and individual producers are engulfed in the lumpen aggregate. Note that the indistinguishability of money is essential for its value-exchange role; yet it is this very indistinguishability that means that the traceability of money (who precisely paid how much for what) is lost.

This loss of information is paralleled in the goods themselves. Open a kitchen cupboard and look at the number of different goods (figure 2.i) compared to a similar volume of supermarket shelves (figure 2.ii).

(i) Kitchen cupboard

(ii) supermarket shelf

Figure 2: Diversity density

Notice how the number of different items in a given volume, the *diversity density* (Dix 2001), is far greater in the kitchen cupboard than on the supermarket shelves. Think now of the lorry supplying goods to the supermarket, or the shelves in the suppliers' warehouses. There may be a whole lorry with just one product.

In 'developed' consumer economies, the diversity density reduces as one moves up the supply chain (Figure 3); basically as the information about who wants what is aggregated the goods themselves are also aggregated. Similarly on the supply side, when grain is accumulated in a merchant's silos, the knowledge of who produced exactly what is being progressively lost.

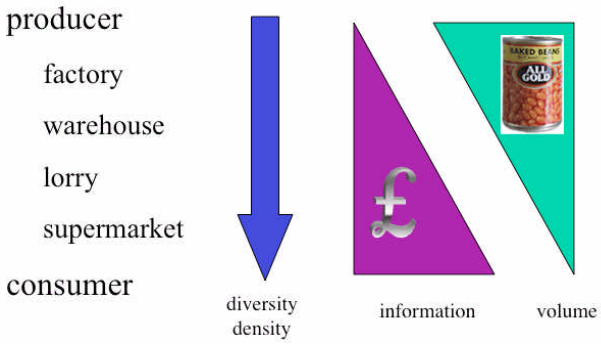


Figure 3: Traditional markets diversity density

The informational role of money has major effects on centralisation and standardisation. Because the aggregation of money loses information about who produced or consumed products or raw materials, there is a natural tendency to treat materials as aggregates in larger and larger quantities. However, in order that products can be aggregated, they need to be fungible; that is, it must be possible to freely substitute one item for another similar one.

When consumers buy directly from a producer, they can inspect each product individually and agree on a price based on the particular apparent and present qualities. As consumer and producer are distanced through money and markets, consumers need to know *what* they are getting even if they don't know from where they are getting it.

The need for fungibility, driven by the economic pressure towards centralisation, has led to a tendency to standardisation of quality, packaging, and weights and measures. This standardisation has sometimes arisen emergently through internal corporate policy and sometimes been imposed

through legislation. An extreme case of the latter is the European Union, which has established some of the most restrictive standards so as to allow easier trans-national trading, but often at the expense of profligate wastage of non-standard goods such as 'mis-shapen' vegetables; happily these regulations are now being relaxed.

Digital Subversion of the Information Role of Money

In some ways Internet sales mirror this longstanding trend towards centralisation and standardisation. Amazon created its brand through the sales of books, themselves an information product and so intrinsically fungible. The rise of Internet shopping for groceries also depends on the fact that customers can rely on the standard quality of the products.

However, both Internet shopping and the increasing use of IT in physical stores are themselves challenging the *information role* of money. For years, through market surveys and consumer intelligence, retailers have tried to obtain more information than is available through money alone. However, IT has made a qualitative change in the nature of this with loyalty schemes and CRM systems meaning companies now know not just what was sold in total, but correlations between items (the famous lager and nappies phenomenon (Strategic Direction 2007)) and even individual customer choices.

Increasingly information about demand, preferences and value is captured, transmitted, stored and processed digitally, not indirectly through aggregated spending trends. Because digital transfer retains more of the information than fiscal exchange, there is more information higher up the supply chain. Diversity density has correspondingly increased further up the supply chain with boxes of mixed and individually selected groceries in the picking lines of online supermarkets (Figure 4).

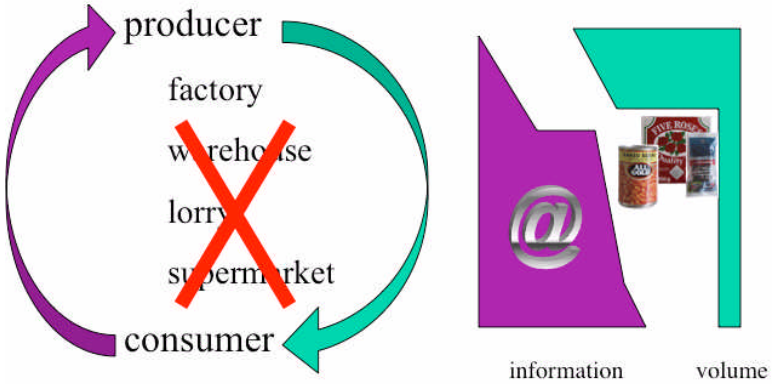


Figure 4: Internet transforming the market

On the production side there are also signs of increased information flow, enabling better tracking of the origins of goods. Sometimes this is simply to improve the efficiency of logistics, for example tracking services of major courier services, and sometimes due to legislation demanding an audit trail of foodstuffs from producer to shop counter. Much of this is enabled by basic technology such as bar codes, but increasingly more embedded micro-technology such as RFID and in the future smart tags that can keep track of the environment so as to better monitor the condition of goods (Strohbach et al., 2004).

Perhaps most radical is the way the global Internet is enabling local-to-local connections. The loss of information inherent in the use of money as information transfer inevitably led to centralised gathering and global distribution. However, the digital transfer makes it possible to directly link producer and consumer who may be physically close and yet not know about each other. Many of the examples of this in developed countries are still at the periphery of economic life, for example, freecycle.org (2009) or craigslist.org (2009). Both of these use a central (global) site to help people find local things; in the case of Freecycle, there is a double environmental benefit: not only is it fostering direct local connections and so reducing transport costs, but also it is about giving away unwanted items, so fostering reuse.

These local-to-local interactions have the potential to transform economic development. Jenson (2007) documents in detail the impact of the introduction of mobile phones on the fishing industry in Kerala, southwest India. Prior to phones being introduced fishing boats landed at their home port, where there would sometimes be a glut of fish leading to wastage, and sometimes a dearth leading to high prices for the consumers. The phones meant that fishing boats could land their catch at different local markets with the best prices, reducing fluctuations in prices across the region and reducing waste.

In western economies this price levelling has largely been achieved through centralisation, due to the relation between diversity density and monetary information; fish would be frozen, transported to central warehouses, redistributed to shops and then sold. In Kerala this was achieved without centralisation, but instead by point-to-point movement of boats due to increased information obtained through the mobile phones. While this involved increased transport costs (and carbon emissions) due to the movements between markets, it is far less than moving all the fish centrally and then redistribution, with associated preservation and storage, which would have been the case under a more traditional ‘developed’ economic climate.

LEARNING LESSONS FROM EACH OTHER

Parallels and Opportunities

While emphasising the potential for different and more sustainable paths of development enabled by IT, it is also important not to underestimate the commonalities of aspiration and need across the world. Understanding these parallels can help the developing world avoid or at least ameliorate some of the pitfalls of the West, but also maybe allow those in developed countries to learn lessons for its problems.

One example is in traditional skills, folklore and languages. There is concern in India that handcraft skills are being lost as children are not continuing their parents' traditional occupations. In addition, of the more than 1600 languages across India (censusindia.gov.in 2009), many are under threat as are the corresponding local traditions, histories and stories. In the UK, the loss of local culture, and craft knowledge happened a long time ago, but now we are seeing a resurgence of traditional skills as a high value, but sustainable, alternative to mass production. Much has been lost forever; however, from the end of the 19th century, folk historians in the UK have collected aural and photographic histories of life, occupations and folklore. In the early days this was managed through paper transcripts, later through magnetic audio recording and cine-film, and more recently exploiting digital media. Learning the lessons from the UK experience, IT offers the opportunity to avoid some of this loss in India and across the developing world.

Another example, but seeing lessons move in the opposite direction, is the well-known Hole-in-the-Wall project (Mitra et al., 2005). This was initially started in 1999 in New Delhi with computers placed to be publically accessible by street children, literally with the screen and keyboard accessed through a hole in a wall. The children in the slum of Kalkaji, where it was first placed, were able to master the use of the technology, without any formal training and minimal support, often tutoring one another in the process. This vindicated Dr Mitra's belief that:

> *"The acquisition of basic computing skills by any set of children can be achieved through incidental learning provided the learners are given access to a suitable computing facility, with entertaining and motivating content and some minimal (human) guidance."* (hole-in-the-wall.com 2009)

The concept has since been replicated successfully across India. However, it has also been used to inspire a similar project in a deprived area of

Newcastle in the UK (Tobin 2009). The details of the implementation are different (e.g. loaned laptops rather than fixed computers), but the needs are similar and the Indian experience has been translated for the UK.

Global Markets

Another parallel is in the hand textile industry in India and the UK; in this case having the potential for forms of direct global producer–consumer interactions.

The Indian hand-loom silk industry is under pressure from cheaper Chinese and local factory-produced saris (Allen 2007). Similarly, in the UK the home textile industry was one of the first casualties of the industrial revolution as the spinning jenny and mechanical loom displaced the spinning wheel and hand-loom (Thompson 1963). The Harris Tweed industry in the western islands of Scotland is one of the few remnants of the hand-loom in the UK and is now itself under threat (MacAskill 2009).

However, isolated communities across the UK have found that the web has opened up markets for hand-produced goods. Here the ability of IT and especially the web to link producer and consumer directly is being used for global interactions. This obviously does not have the same environmental transport benefits as local-local connections, but, for light and easy to transport goods, this can offer both economic benefits and also social and cultural ones as communities are maintained and feel their work is valued internationally.

The hand-produced silk that is facing such stiff competition in India, could be of high-value if sold globally through the web. However, while in the UK, even in isolated rural areas, there is ready access to Internet connected computers and IT education, in contrast, in the Indian context, those areas most in need are those least likely to have access to this technology and expertise. Happily mobile-phone access to the Internet is expected to become ubiquitous on the near future, and this may offer ways to allow access to global markets.

Of course this is not simply an issue of available hardware; software and financial systems have also to be in place. There are existing models of point-to-point connectivity, notably eBay, but of course currently predicated on the possession of a credit card. Amazon's print-on-demand service, whilst being a central service itself, is interesting in allowing very low-cost entry into publishing by individuals and small groups, managing the connectivity and payment processes. When considering

direct consumer-producer connectivity into developing areas, many issues such as language arise, but perhaps most critically, new ways to manage online financial transactions, for those below the normal income level of credit cards or even bank accounts.

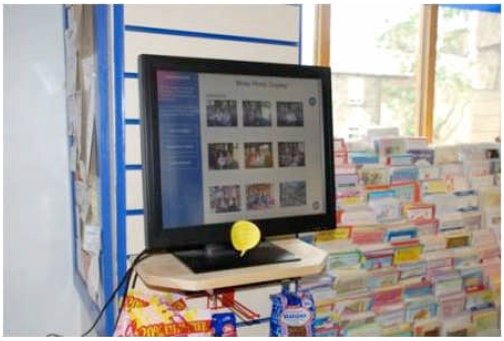
Culture and Community

In western countries the growth of mass media has often exacerbated the decline in local culture and tradition, which began during the economic migration and urbanisation of the 19th and 20th centuries. The global Internet has often increased this trend, taking people away even from national culture towards an increasing global homogenisation. However, there are also counter-trends, such as local-language TV broadcasts. In the UK the introduction of pure Welsh language TV channel was the end point of a long movement of non-violent protest up until the early 1980s.

At a cultural level the Internet is already being used by many local communities in developed countries to reassert their identity: recording local history, folklore and craft; relaying current events and news, and reaching out to their diaspora and the world. With large-scale economic migration, especially of the young, also common in many developing countries, emerging access to mobile internet opens up similar possibilities.

The early strength of the industrial revolution has meant that this process of local culture loss, especially rural culture, was already well advanced when the pioneers of community history began their tasks. However now community history of both the distant and recent past is a major issue, for example, the first author lives on a small island of 750 people, but it has its own local history centre both for local historians and tourism. This need to root ourselves seems a universal phenomenon and is the focus of various Indian projects. Some are largely based around more traditional technology, such as the Adivasi Academy, a museum dedicated to educational programmes and preservation of tribal culture (Coates & Coates 2005); others adopt more advanced technology, such as the StoryBank project, which used mobile handsets and computers to promote digital storytelling in a small village near Bangalore (Jones et al. 2008).

As well as recalling and recording the past, end-user content is also often about recent or current events. This is the case both in the UK, for example, in the Wray Village Photo Display (Figure 5) a rural community development project developed at Lancaster University (Taylor et al., 2008); and also in India, for example, the StoryBank project was about current as much as past experience (Jones et al. 2008).



[[N.B. currently checking permissions for the StoryBank image]]

Figure 5**:** Wray Village display (Taylor et al., 2008) and StoryBank (Jones et al. 2008)

DISCUSSION – WILL IT ALL JUST HAPPEN

If, as we have argued, IT has the potential to improve economic, environmental and social sustainability, will this just happen anyway? In other words while the path for development in India and other developing countries need not be the same as for the west, is there still a single inevitable path driven by economic and other forces? Certainly the experience in the UK suggests that benefits do not just 'happen', and from an economic point of view IT has so far tended to offer the first and greatest benefit to those who are most well off and those in urban areas. More generally Moriset and Malecki (2008) note out that '*the geography of telecommunications networks tends to replicate those of transport infrastructures*', in other words IT reinforces existing economic disparity.

Jensen's case study of the Kerala fishing industry demonstrated that direct consumer-producer information, in this case by mobile phone, can transform a local economy (Jensen 2007). Jensen was keen to point out that there was a *net welfare benefit*; that is on average everyone was better off. In fact, he showed that things were better than this. Not only was the average better, but in fact profit increased both for boats with mobile phones (the larger and more prosperous ones), but also for those without. In addition, the consumers onshore were very slightly better off, paying *on average* less per kilo of sardines.

This is at first surprising as the introduction of phones meant that fishing boats travelled further, so spent more money on fuel, and also had to purchase phones, so if anything money flowed out of the local economy

and so it is odd that *everyone* could benefit. However, crucially the level of wastage was substantially reduced: in the past boats often discarded catches when there was a glut of fish or when buyers went home when the boats were late, but with the use of phones allowed the catch to be spread more evenly over the markets in the region, and for sales to be concluded even when the boats were still at sea. More fish was landed and sold, hence the average price to the consumers could be lower and the fishing bats could increase profits.

However, this net welfare benefit hides potential differential effects on different consumers. Jensen explicitly suggests the possibility that some consumers might simply choose only to buy on days when the fish price was low. He introduces this largely to argue that if everyone did it the price would have naturally stabilised which was not observed. However, it seems likely that a minority will have behaved exactly like this; the common practice amongst the poorest in any community (including the UK) is to look for the things that for some reason cheapest on any particular day.

One of the measures of the economic 'success' of the introduction of the phones was the reduction in day-to-day variability in fish prices. The graphs in Jensen's paper are very impressive (Jensen, 2007, Figure IV) showing massive variability before phones (62-69% of the mean price) and nearly stable afterwards (<14%). Considering the poorest consumers, before the introduction of the new technology, so long as they were prepared to only buy sardines on average every other day, then they could pay less than half the long-term average price by selectively buying on the cheaper days. After the introduction of the phones, they could at best pay 90% of the average price by selective buying. That is, while, the average consumer paid less, the poor potentially suffered a *doubling* in the price they paid. Whether this was a major issue in Kerala is not reported, maybe as it is a relatively prosperous state it was not an issue. Critically the traditional economic analysis of the situation did not even consider the question.

This is not simply a one-off example; traditional market economies naturally 'optimise' production due to the hidden hand effects of the informational role of money. However, this maximising of efficiency of production is not uniform. Markets operate most efficiently for the groups with the largest total spending power. In western economies this tends to be the middle-income groups. For both the rich and the poor the 'optimising' effect is less strong (less total spending power) and hence things are produced less efficiently for them. For example, the cheapest food prices are typically available in large out-of-town supermarkets, which are only

accessible by car; for those who cannot afford a car the smaller neighbourhood shops are substantially more expensive for the same food items. Mendoza (Mendoza 2008) shows that this trend for the poor to pay more is seen across developing countries with the 'poverty premium' (the amount that the poor pay over and above the more affluent) ranges from 20% to 4000% (40 times as much) depending on the product or services concerned. This is in part one of the reasons why, across the world, the gap between rich and poor has been growing in recent decades (Prahalad & Hart 2002).

However, wherever there are sufficient concentrations of groups (whether economic or interest based) then micro-markets form and tend to optimise for them. In the past these have needed to be geographic concentrations, but increasingly the internet is creating virtual micro-markets, thus allowing more efficient production and distribution of goods for those with minority interests, but of course helping more those who are more affluent and so have access to the web and credit cards.

Prahlad (2004) in 'The Fortune at the Bottom of the Pyramid' suggests that there is a substantial entrepreneurial opportunity in focusing on the poorest in the world, and offers numerous case studies where this has been done successfully. However, the book would not have needed to be written if this were the norm rather than the exception. For the ambitious entrepreneur there are usually more easy profits to be made from first addressing more affluent markets.

While suitable IT has the potential to transform traditional economic development, making sure it does so for the benefit of the poorest, may require more direct intervention. For example, if there were a suitable financial and IT infrastructure then maybe the poorer parts of society in developed and developing countries could benefit from micro-markets dedicated to their needs. Prahalad and Hart (2002) note that banking and finance for the poorest segments need greatest IT support, and some of this is already emerging. However, the complete infrastructure may not develop by leaving it to the markets alone. For example, Svensson and Yanagizawa (2002) describe a service delivering information on maize prices using FM radio in Uganda; this substantially improved the conditions of otherwise information-poor small farmers. Similar gains were reported by Ashraf et al. (2008), who found that an NGO-provided package of information and credit facilities enabled farmers in Kenya to more effectively access export markets. More broadly, Clark (2001), argues that it is only in a deep understanding of information that it is possible for institutions to provide effective agricultural knowledge in the developing world.

While this discussion has focused on the social and economic issues, we believe a similar message is true for cultural and environmental issues.

CONCLUSION

We have seen how IT provides technology that can be used to aid in economic, environmental, and social sustainability: including examples of saving resources, culture and language. IT alongside other advanced technologies enables development paths for emerging economies that are not simply re-iterating those of the developed world, which have created the current global crisis. Of particular importance both culturally and economically is the way global networks enable not only global interactions but also rich local–local interactions. Perhaps most radically, IT changes the very role of money itself: by eroding the informational role of money, digital information offers the potential to create new forms of economic connectivity, in particular more direct consumer-producer relationships. However, we have also seen that the beneficial use of IT is far from inevitable; establishing the necessary infrastructure, and relevant technologies may need explicit action, not simply be left to chance. There is not a single inevitable linear path of development we have to follow, but amongst those paths made possible by technology, *we have to choose* which to take.

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