The impact of ICT on sustainable development

This paper has been provided by Forum for the Future in close co-operation with the EITO Task Force.

1. General overview

The chapter aims to:

- introduce the concept of sustainable development;
- examine the impacts and opportunities created for sustainable development by the rapid penetration of ICT into society and culture;
- suggest the means for mitigating adverse affects and encouraging positive outcomes for all in the penetration of ICT.

An innovative framework has been developed that allows a detailed and comprehensive analysis of the environmental, social and economic effects and opportunities of ICT in the context of sustainable development.

The chapter will conclude that in some cases ICT is of direct benefit to the goals of sustainable development, and in others detrimental. In most cases, however, the overall effects will only become clear in the medium to long term.

It is shown that despite its great potential, ICT is not in itself a force for sustainable development, but has both positive and negative effects. In order to maximise the positive effects and minimise the negative, the development and application of ICT should be guided by policy makers in government, business and civil society.

2. What is sustainable development?

Although there are many definitions of sustainable development, the most commonly quoted comes from the Brundtland Commission's 1987 report, "Our Common Future". Here, sustainable development is defined as "development which meets the need of the present without compromising the ability of future generations to meet their own needs".[1]

This chapter defines sustainable development as:

A dynamic process which enables all people to realise their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life-support systems.[2]

Implicit here is that economic, social and environmental dimensions are equally vital and inter-connected:

- *Economic* sustainability means economic growth without making undue demands on social or natural resources.
- *Environmental* sustainability means not only minimising impacts on the environment, but building natural resources and safeguarding them for the future.
- *Social* sustainability means building, and not undermining, social equity.

[1] Brundtland Commission, "Our common Future", 1987

[2] Forum for the Future definition of sustainable development.

Together these three spheres of sustainability are commonly referred to as "the triple bottom line", a term first coined in 1997 by John Elkington, director of the sustainable development consultancy SustainAbility.[3] As well as setting goals for economic performance, businesses and economies should also set social and environmental performance goals. Most importantly, performance in one sphere should not undermine performance in the other two.

2.1. Sustainable development and ICT

The growing acceptance of sustainable development as a goal and the progress of ICT share many characteristics as drivers for change within modern economies. Both require us to rethink the nature of goods and services and both have the capacity to transform the relationship between governments, companies, citizens and consumers. However, there have been surprisingly few attempts to assess whether the growing acceptance of the sustainable development agenda and the growth of ICT will complement or conflict with one another.

2.1.1. Sustainable development and ICT policy convergence

Figure 1 illustrates convergence between the two policy agendas for sustainable development and the Information Society.

With the Information Society and sustainable development both policy priorities, integration between the two policy agendas should be inevitable. The Lisbon agenda refers to economic sustainability and social cohesion, and the eEurope Action Plan places significant emphasis on social inclusion in the Knowledge Society through investment in people and skills. The conclusions of the Göteborg European Council refer to the need to "promote innovation to develop new technologies which use fewer resources and reduce pollution".

Yet the potential for integration between policies on sustainable development and the transition to *e*Europe remains under-exploited.

ICT presents opportunities to resolve traditional trade-offs between economic growth, the environment and social cohesion. Equally, there is the opportunity to integrate sustainability criteria into the Information Society at an early stage in its development, maximising the social and environmental opportunities of ICT and mitigating its adverse impacts.

2.1.2. Challenges in integrating the agendas of sustainable development and the Information Society

In assessing the overall sustainability impacts of ICT, several challenges must be considered:

- The development and application of ICT through the economy and society is as yet at an early stage. It is still only possible to take an educated guess as to the medium- and long-term effects.
- ICT is pervasive and enabling and, by any measure, is advancing rapidly in terms of power, performance and affordability. These trends are unlikely to change in the near term. ICT drives the advance of other new technologies, whose impacts need to be assessed separately. Radical new technologies such as biotechnology have the potential to entirely change the current terms of reference of the links between ICT, the economy, society and the environment.
- ICT is constantly giving rise to new social phenomena which need to be factored into the equation. One example is the development of online communities.

[3] Elkington, J. "Cannibals With Forks: The Triple Bottom Line of 21st Century Business", Capstone, Oxford, 1997

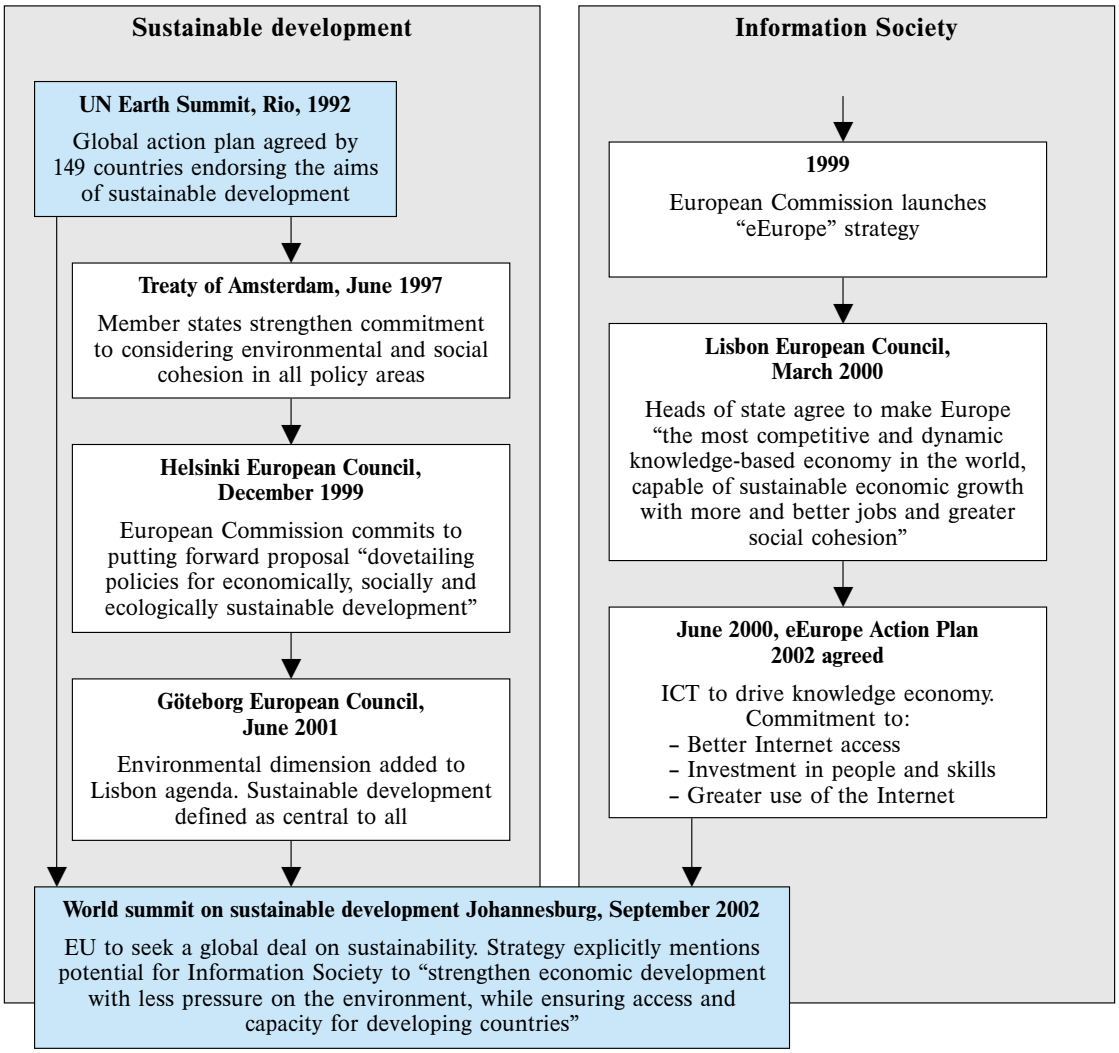


Figure 1
Sustainable development and ICT policy convergence

- In response to the development of ICT, new regulations are constantly coming into force. By channelling the development of ICT in a particular direction, regulations may promote or impede synergies between ICT and sustainable development. The effects of new regulation need to be understood and factored into new research being undertaken.
- Despite the growing body of research, many data gaps still exist and there is much disagreement in certain areas.

3. The framework for analysis

Research to date into ICT and sustainability has failed to create a conceptual framework that presents an aggregated picture of the impacts and opportunities of ICT and sustainability over time. Without such a framework, determining how to maximise the potential opportunities and minimise the negative impacts of ICT and sustainable development is problematic.

For the sake of clarity the three-spheres model of sustainability has been used, based on Elkington's triple bottom line as described above. Since these spheres in reality exist in a dynamic relationship, the evaluation stage at the end of this chapter will be an opportunity to make broader, overall assessments for sustainability as a whole, highlighting the linkages across the triple bottom line.

The effects of ICT have also been separated according to the different stages in their development and deployment. This allows the identification where possible of how a positive opportunity may over time have a negative spill-over or vice versa and hence where action could be taken to maximise the positive outcomes. Effects are divided into first, second and third orders, as shown in *Table 1*.

Within each cell of the framework, key areas have been selected that demonstrate the extent of existing understanding. While positive effects cannot be categorically separated from negative, where possible attempts are made to highlight the current balance between the two.

	Impacts/opportunities sphere			
Sustainability sphere		**First order** The impacts and opportunities created by the **physical existence of ICT and the processes involved.** This includes the design, manufacture, operation and disposal of ICT.	**Second order** The impacts and opportunities created by the **ongoing use and application of ICT.** For example, this includes E-business.	**Third order** The impacts and opportunities created by the **aggregated effects of large numbers of people using ICT over the medium to long term.** For example, this includes the changing nature of relationships between business and markets.
	Environmental	Section 4.1	Section 4.2	Section 4.3
	Social	Section 5.1	Section 5.2	Section 5.3
	Economic	Section 6.2	Section 6.3	Section 6.4

Table 1
The framework for analysis

4. Environmental sustainability and ICT

Table 2 below summarises the environmental effects and opportunities created by ICT.

First order effects	Second order effects	Third order effects
Design and manufacture of ICT equipment – ICT production is a relatively lightweight industry – Use of toxic components – New waves of technology are more energy-efficient	**Increase and decrease in use of transport** – Increase in home deliveries as a result of E-commerce will have significant environmental impact unless well co-ordinated – Telework reduces travel miles for employees – Telematics reduces traffic congestion, journey times and therefore pollution – Rebound effects from increased leisure travel	**De-coupling economic growth and energy consumption** – Possibilities of reducing energy used per unit GDP
Operation of ICT equipment – Energy use even in stand-by mode	**ICT in business systems** – B2B E-commerce and ICT-managed control systems create efficiencies and reduce environmental impact	**De-coupling economic growth and carbon emissions** – Possibilities of reducing carbon dioxide emissions per unit GDP
Disposal of ICT equipment – Problematic disposal – Recycling and safer designs increasing	**Virtualisation of material products** – Possible environmental savings from increased trade in intangibles	**Changing settlement patterns** – Conflicting pressures on local settlement – Possible increase in environmental pressure on regions
	Effects on product lifetimes – Some E-commerce business models extend product lifetimes – Product development cycles are often reduced by use of ICT	
	Distribution and manipulation of environmental information – Significantly enhanced by ICT	

Table 2
Environmental sustainability and ICT

4.1. First order impacts and opportunities

Production of ICT equipment does not place the same level of demands on natural resources, nor is it as polluting, as many other industries. The design, manufacture, operation and disposal of ICT does however have an overall negative impact on the environment, although some action can be taken to mitigate these impacts.

4.1.1. Design and manufacture of ICT equipment

There are elements included in the design and manufacture of ICT that could be seen as unsustainable.

Damaging materials are used in ICT components, for example:

- The batteries in mobile telephones contain toxic metals such as lithium or cadmium. The ores of such metals must be quarried and then undergo lengthy and expensive refinement processes, causing significant environmental disruption.
- Cathode ray tubes contain large amounts of lead, shown to have high levels of toxicity.
- Many devices are coated with flame retardants that contain toxic compounds.

The manufacture of ICT equipment is resource-intensive:

- One study showed that the production of the average computer chip requires 45.46 litres of water, used primarily for washing. One chip plant in the USA uses between 4.5 and 13.5 million litres of water a day.[4]
- A study for the European Union in 1998[5] suggested that the production of a personal computer, including material production, manufacture and distribution, would lead to the release of 0.19 tonnes of greenhouse gases, 36 kg of overall waste, and require 3.6 GJ of energy.

Efforts are being made to minimise the amount of resource needed in the production of ICT. This makes economic as well as environmental sense.

- More efficient chips mean more processing power for the amount of resource/energy required. Every generation of chips reduces in size by approximately a factor of 0.7.[6]
- Mobile telecoms network operators are investigating the possibility of using renewable or low-impact energy sources to power base stations.
- The manufacture of mobile phones now incorporates measures such as material identification and easy disassembly, to make recycling easier.

4.1.2. Operation of ICT equipment

Operation of ICT equipment accounts for the greatest demands on energy and natural resources. For example, the use phase of a personal computer in the EU has been calculated to produce 0.45 tonnes of greenhouse gases, 108 kg of waste and 10 GJ of energy per unit[7] – significantly more than in the production process, as *Table 3* illustrates.

[4] http://www.news-journalonline.com/2001/Apr/30/AREA1.htm. Although a large proportion of this water can be reused for other purposes, no microchip manufacturers currently recycle water for reuse in the washing process, as the water must be pure and particle-free.

[5] Atlantic Consulting (1998), "LCA study of the product group personal computers in the EU Ecolabel Scheme"

[6] Schauer, T., "What are the conditions for a sustainable Information Society?" In: Towards a Sustainable Information Society: Report of the Conference on 21–22 February 2000

[7] Atlantic Consulting (1998), "LCA study of the product group personal computers in the EU Ecolabel Scheme"

	Production phase	Use phase	Disposal phase
Greenhouse gases	0.19 tonnes	0.45 tonnes	0.022 tonnes
Waste	36 kg	108 kg	21 kg
Energy	3.6 GJ	10 GJ	–

Table 3
Operation of ICT equipment

When it is considered that PC penetration in the European Union is currently around 40%, personal computer use in absolute terms is clearly extremely resource-intensive.[8]

The impact on energy demands at the first order is only likely to increase in the short and medium term, as ICT becomes more embedded in society, types of device and the functions they perform proliferate, and as penetration around the world deepens.

Server farms

"Server farms" – massive banks of computers used to store the information that appears on Websites – concentrate the use of large amounts of energy, that would otherwise be more widely dispersed. While this provides economies of scale, a single server farm can consume as much electricity as a small airport or four large hospitals. Where server farms are concentrated, as in Silicon Valley or London, they can be serious drains on local electricity supplies. To combat this, one purpose-built server farm outside London is currently being built with a dedicated 24 MW gas-fired power station to supply all of its energy needs. It has been suggested that renewable energy sources could be used instead in future projects of this type.[9]

4.1.3. Disposal of ICT equipment

The average lifetime of a PC used for business purposes is three years, and in Europe the replacement cycle of a mobile phone is 18 months. As technology moves on and more functions and capacity are offered, the number of obsolete or undesirable products increases.

In 2000 the European Commission estimated that the EU produces six million tonnes of Waste Electrical and Electronic Equipment (WEEE) a year. A report by the Industry Council for Electronic Equipment Recycling[10] put the UK figure alone at one million tonnes, 90% of which was large ICT equipment.

Dealing with electronic waste without damaging the environment is a major challenge. Much ends up eventually in landfill sites, where polluting substances used in ICT components can leach into the ecosystem.

As long as toxic substances are used in the design and manufacture of ICT, the most effective means of preventing them entering the ecosystem is through providing take-back and recycling schemes. Many parts of ICT waste are recyclable, but the structures to ensure that recycling takes place on a significant level are not yet widely in place.

Consequently, there have been calls for policy initiatives to make recycling of ICT in general and toxic components in particular, mandatory. Encouragingly, the EU's WEEE directive, which is expected to become law in 2002, will require producers to ensure that 65–80% of electronic waste is recovered and recycled.

4.2. Second order impacts and opportunities

The application of information and communications technology has a more ambiguous effect on the environment than that of the creation of the equipment. In many areas it may create efficiencies leading to "dematerialisation": a reduction in the quantity of natural resources required to support human activity.

[8] http://cyberatlas.internet.com/big_picture/geographics/article/0,,5911_429391,00.html

[9] "The Internet's new borders", The Economist, 11 August, 2001

[10] ICER, "ICER status report on WEEE", March 2000

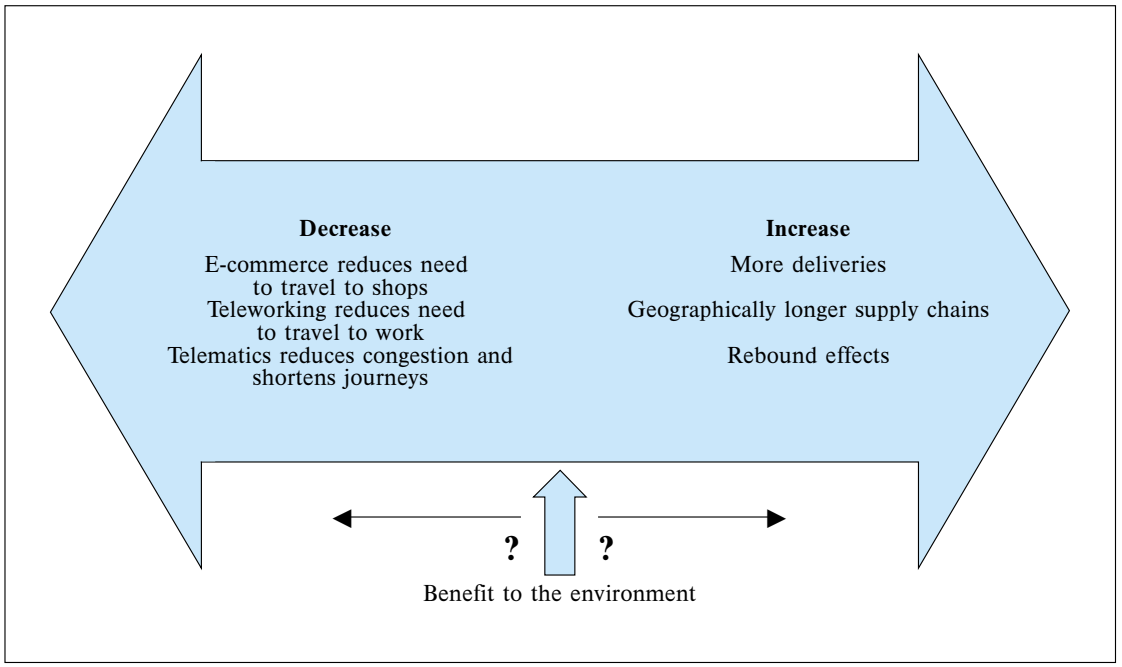


Figure 2
The effects of ICT on the use of transport

4.2.1. Increase and decrease in the use of transport

There is conflicting evidence of the impact of ICT on travel. *Figure 2* shows that, while E-commerce and telework reduce the need to travel and telematics systems may make car transport more efficient, counter-trends exist, and the balance of benefit to the environment has yet to be established.

i. E-commerce and travel

Home shopping over the Internet should reduce the need for consumers to make car journeys to shops. According to the National Economic Research Associates, home shopping will reduce car-based shopping travel by 5% by 2005 and 10% by 2010.[11] The consequent reduction in vehicle emissions would be significant.

However, once the corresponding increase in delivery traffic and extended supply lines are factored in, the picture is slightly different. A study commissioned by the Netherlands government predicted that if E-commerce makes up 11.5% of retail sales by 2005, road traffic will increase by 17%.

The main variables to consider in the equation are the methods of product delivery, the uptake of B2C E-commerce and the consequent changes in consumer leisure habits.

As a recent report from the UK government's Foresight research programme shows, there is much to be gained from co-ordinating home deliveries to minimise the distance travelled, for example by utilising local drop-off points rather than delivering directly to homes, and through co-operation between different retailers.[12]

[11] "Motors and Modems Revisited", NERA, London 2000

[12] "@ Your Home". According to a study by the Swedish University of Agricultural Sciences, co-ordinating the delivery of stock to 15 different locations using ICT reduced the total distance travelled by 39% and the number of journeys by 58% (Lennart Forseback, Case Studies for the Information Society, IST, May 2000).

The net effects on transport will remain unclear however until B2C E-commerce is properly established. The eEurope Action Plan Benchmarking Report 2001[13] shows that currently in the EU as a whole fewer than 5% of Internet users make online purchases regularly, approximately 1.7% of the population.

ii. Telework and travel

Remote working using the Internet to access office systems, for example via Virtual Private Networks or using teleconference and videoconference technology,[14] has been possible for a long time. A barrier to widespread take-up has been the lack of broadband access in homes, but in some parts of Europe broadband availability is increasing rapidly.[15]

When promoted by employers, teleworking has been shown to significantly reduce travel miles. One Swedish company with 200 employees has managed to reduce home-to-work travel by 74,000 km a year.[16] One major European telecommunications company now has 4,000 homeworkers who between them save approximately 12.5 million commuter miles per annum – equating to a saving of 1,000 tonnes of carbon dioxide emissions.[17]

iii. Telematics: efficient transport using ICT

One means of ensuring more efficient travel patterns for all vehicles is the utilisation of telematics systems. The term telematics has evolved to refer to in-car systems that combine Global Positioning Satellite (GPS) tracking and other wireless communications including access to the Internet. The most significant application of this technology is Intelligent Traffic Guidance Systems (ITGS). ITGS can plot the quickest or most efficient route from A to B, taking into consideration traffic flow systems such as one-way streets or speed controls and, more importantly, avoiding areas of congested or slow-moving traffic. The effect is to significantly reduce congestion and travelling time, and therefore vehicle emissions. ITGS was shown to reduce travelling time in rush hours by 50% compared to conventional static navigational systems.[18] The Dutch government aims in its programme, "Telematics in traffic and transport" to reduce vehicle miles within the Netherlands by 25% in the period 1998–2003, in part through its use of ITGS.

iv. Rebound effects

The application of ICT in trade, work and travel systems could on balance cut the demands of transport on the environment. However, it is unclear what consumers do with the time that they save by ordering goods online rather than making a car journey to the shops, or what teleworkers do with the time they save by not driving to work. Is this extra time used to make additional journeys by car, for leisure purposes perhaps, that otherwise would not have been made? Similarly, when drivers see open roads and free-flowing, telematics-controlled traffic, will they be tempted to drive more, in the same way that building more roads seems to create more traffic? These "rebound" effects pose complex research questions that must be answered before the net contribution that ICT is making to environmental protection can be accurately judged.

4.2.2. ICT in business systems

ICT has had a positive effect on business efficiency, for example through:

- consolidating supply chains through the use of B2B E-commerce portals;
- use of E-procurement in larger organisations, bringing economy of scale savings;
- use of computer-driven management systems and the implementation of databases;

[13] http://europa.eu.int/information_society/eeurope/benchmarking/index_en.htm

[14] Telephone and video-conferencing at BT has created savings of 150 million miles across all modes of transport and avoided emissions of another 34,000 tonnes of CO_2. For more information see James Wilsdon (ed.), "Digital Futures: an agenda for a sustainable digital economy", 2001

[15] See "The Development of Broadband Access Platforms Across Europe" report for the European Commission, available at http://www.europa.eu.int/information_society/eeurope/news_library/

[16] Lennart Forseback, "Case studies of the Information Society and Sustainable Development", May 2000

[17] James Wilsdon (ed.), "Digital Futures: an agenda for a sustainable digital economy", 2001

[18] Schauer, T., "What are the conditions for a sustainable Information Society?" In: Towards a Sustainable Information Society: Report of the Conference on 21–22 February 2000

- use of telematics in manufacturing processes;
- use of ICT to monitor office systems such as air-conditioning.

An office supply company established an Internet-based invoicing system and cut the amount of paper it used from 13 million sheets a year to one million sheets a year.[19]

Such systems are generally introduced into companies because they represent medium-to long-term cost savings. Often however, cost savings are reflected as environmental savings, as more efficient processes require less energy and create less waste.

For example, an efficiency programme using heating, ventilation and air-conditioning control systems in a New York college saved € 11.2 million at the same time as cutting energy use by 20,000 kilowatts[20] and carbon dioxide emissions by 48,000 tonnes.

4.2.3. Virtualisation of material products

The application of ICT can decrease the amount of material products circulating in some areas of the economy. "E-books", which exist only as downloadable electronic files, are one example: Penguin books planned to have 200 titles available electronically by the end of 2001. The result could be the use of less paper in the publishing industry, less glue for binding, less filler for glossy pages, less freight on the transport network and so on. The technology used by MP3 files similarly could result in the production of fewer CDs. Likewise online banking means that printed statements are no longer necessary.

The energy use of the Internet

The Internet is central to hopes for a "weightless" new economy, but a heated debate rages over the real energy demands it exacts.

Mark Mills in a Forbes article, "The Internet begins with coal"[21] asserted that use of the Internet accounts for as much as 8% of the total electricity demands of the US, and that therefore energy capacity in the US needs to be increased to meet the demands of the new economy. Others[22] have maintained however that the figure is much lower, at around 1–2%. The only European study to date was conducted by the Wuppertal Institute in Germany in 2000. It estimated that use of the Internet accounted for 1% (4,000 Gigawatts) of Germany's electricity demand.[23] The institute is now conducting research to show the energy implications of one hour of Internet use.

The broad range of estimates is due partly to a lack of information about levels of usage. Also crucial is where the boundaries of use are drawn: should analysis stop at the direct energy consumption of PCs, networks and servers, or should it be extended to include second and third order effects, where the data is more ambiguous?

However, in practice, the virtualisation of products may be balanced by a counter-process of "devirtualisation" in which E-books and online bank statements are printed out and MP3 files burned onto CDs. If enough virtual products are subsequently devirtualised, the net impact on the environment is much greater than if no virtual products existed in the first place: the resources used in producing the virtual product are added to those used when consumers

[19] Financial Times article Thursday 6 December 2001

[20] http://www.nypa.gov/

[21] Mark Mills, "The Internet begins with coal: a preliminary exploration of the impact of the Internet on electricity consumption", 1999

[22] Joseph Romm, "The Internet economy and global warming", Center for Energy and Climate Solutions, 1999; Koomey et al., "Initial comments on "The Internet begins with coal", 1999

[23] Barthel, C., Lechtenböhmer, S. und Thomas, S., www.internet.CO_2, Wuppertal Institute, 2001

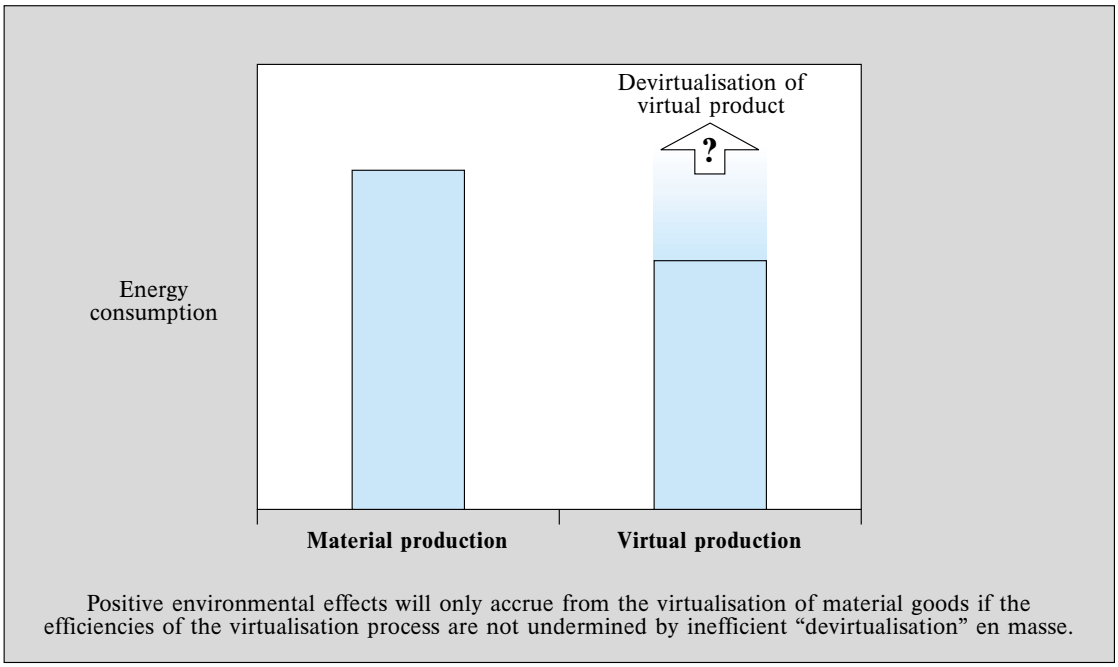


Figure 3
Virtualisation of material products

Positive environmental effects will only accrue from the virtualisation of material goods if the efficiencies of the virtualisation process are not undermined by inefficient "devirtualisation" en masse.

produce the material product themselves in a process where the efficiencies of large-scale, centralised production are lost, as illustrated in *Figure 3*.

4.2.4. Effects on product lifetimes

Use of ICT in the design and manufacturing processes of a wide range of products creates shorter product cycles. New products can be designed and produced at a faster rate and so become obsolete sooner.

However, ICT also offers the opportunity to extend product lifetimes by facilitating online exchanges. For example, online auction sites are able to put an unprecedented number of buyers and sellers in contact with each other. One such site claims 30 million registered users and 5 million items for sale worldwide at any one time.

In similar fashion, ICT provides the means for producers to match supply and demand more closely and so reduce wastage through over-production. Many seats go unoccupied in aeroplanes for example. Some E-commerce sites offer these seats at a lower price and thereby increase the running efficiency of the airlines.

4.2.5. Distribution and manipulation of environmental information

The distribution and manipulation of environmental data has been enhanced by ICT. The availability of this data has been invaluable in making the case for and enabling environmental action.

ICT has been used to collect, collate and deliver the data that provides evidence of environmental decline: the amount of rainforest being cleared in Brazil, the level of greenhouse gas

Table 4
Electricity consumption per capita[24]

Electricity consumption per capita	1980 (kilowatt-hours)	1998 (kilowatt-hours)
Austria	4,371	6,175
Belgium	4,402	7,249
Denmark	4,222	6,033
Finland	7,779	14,129
France	3,881	6,287
Germany	5,005	5,687
Greece	2,064	3,739
Ireland	2,528	4,760
Italy	2,831	4,431
Luxembourg	9,803	12,400
Netherlands	4,057	7,322
Norway	18,289	24,607
Portugal	1,469	3,396
Spain	2,401	4,195
Sweden	10,216	13,955
Switzerland	5,579	6,981
UK	4,160	5,327

emissions in Europe, ultraviolet radiation in Antarctica and so on. Making much of this data available on the Web has given a wide community of researchers and policy makers the resources to carry out their work and make the arguments that have put the environment on the agenda. The understanding of the process of global warming would be dangerously superficial were it not for the use of powerful computers in developing climate change models, for example.

ICT has enabled and will enable action to be taken to halt environmental decline. The Kyoto Protocol on climate change in 1995 established the principle of global emissions trading, to allow countries that have not been able to reduce emissions to compensate those that have. The complex calculations necessary for this would not be possible without ICT.

4.3. Third order impacts and opportunities

The aggregated effects of the widespread use of ICT on the environment are difficult to identify and to measure. They depend very much on how the increasing use of ICT in all aspects of human activity effects consumption and economic efficiency. As ever, though, isolating the effects of ICT from those of other social, economic and technological trends is problematic and prevents us as yet from reaching any form of confident conclusion.

4.3.1. De-coupling economic growth and energy consumption

Evidence for the de-coupling of economic growth and energy consumption is conflicting. One study[25] argues that whereas traditionally GDP growth in the US has been directly correlated to growth in energy demand, in 1997 and 1998 the US economy grew by 8% but energy demands grew by only 1%. If there had been no structural changes to the economy, a 6% increase in energy demand would have been expected in this period. The authors of the study attribute the discrepancy to the increasing use of ICT.

However, electricity consumption per capita increased in Europe between 1980 and 1998 as *Table 4* shows. While energy intensity per unit of GDP generally decreased in developed countries, it is problematic to identify increased use of ICT as the driving factor rather than other structural changes in the economy or direct attempts to conserve energy.

[24] UN Human Development Report 2001, Human Development Indicators, p. 200

[25] Romm, "The Internet Economy and Global Warming: A Scenario of the Impact of E-commerce on Energy and the Environment", 1999

4.3.2. De-coupling economic growth and carbon emissions

Similarly, although research has predicted that dematerialisation of the US economy through the adoption of E-commerce will lead to a net 2% per annum reduction in CO_2 emissions between 2000 and 2007,[26] rigorous evidence for this elsewhere is conflicting. Carbon dioxide emissions per unit of GDP, a good indication of the carbon intensity of an economy, have decreased in most European countries by between 20% and 50% in the past two decades.[27] However, it is impossible to determine whether this has been due to ICT applications or a range of other factors.

4.3.3. Changing settlement patterns

Processes that derive from the production, use and application of ICT – dematerialisation, telework and E-commerce for example – could have a far-reaching effect on patterns of human and industrial settlement.

Agglomeration

Effective use of ICT means that space can be used more efficiently: with E-commerce, there is less need for physical shops and banks. Offices need less space and, with less traffic, better use can be made of car parks and roads. This leads to a more compact settlement and fewer demands on natural resources.

Dispersion

Although no one has suggested that humans can do away with the need to meet and socialise completely, most agree that, through making telework possible, ICT has reduced the *need* to congregate. It becomes easier to live in suburbs, the commuter belt or even in a peripheral region and do the same work. This process may encourage dispersion of activities and therefore an increase in demands on natural resources.

The adoption of ICT at a local level produces two conflicting pressures: agglomeration and dispersion.

It remains to be seen which of these processes is the more powerful, or indeed if either process has any significant effect while planning laws in most countries remain strict and focused on the carefully structured development of compact settlements.

On a regional level, it has been conjectured that traditional infrastructure such as roads and railways are less important for economic development than the presence of ICT network. The result may be to reduce the economic importance of geographical location within countries and regions. E-workers can theoretically be located anywhere they can access the Internet, as can ICT companies. The logical extension is that more environmental pressure is placed away from the traditional core of economic activity, with the necessary development of land for housing and amenities.

There is little evidence at the moment to support this conjecture. Indeed, a study by Boldly-go.com in the UK showed that, rather than being distributed equally across the country, dot.com companies were concentrated in zones of traditional economic power: 80% were located in the south east of England, with 60% in London.[28]

5. Social sustainability and ICT

Table 5 summarises the social impacts and opportunities created by ICT.

5.1. First order impacts and opportunities

While the design, manufacture and operation of ICT has created some jobs in some areas, the uneven distribution of the technology

[26] Romm, "The Internet economy and global warming: A scenario of the impact of E-commerce on energy and the environment", 1999

[27] OECD "Key Environmental Indicators", p. 29

[28] James Wilsdon (ed.), "Digital Futures: an agenda for a sustainable digital economy", 2001

Table 5
Social sustainability and ICT

First order effects	Second order effects	Third order effects
Job creation – Jobs created in production of ICT equipment	**Access to information** – Health information available online – Government information available online	**Cultural homogeneity or cultural diversity?** – ICT promotes homogeneity and diversity at the same time
Digital divide – Discrepancies in distribution of access to ICT	**Security challenges** – Risk to users of Internet – Internet also used by criminal groups	**Building local communities** – ICT may bolster local communities
	Access to better services – Health services, E-learning, Government services, E-commerce and telework create opportunities for social inclusion	**Building civic culture** – ICT may encourage popular participation in community affairs
	New communities online – Internet enables new types of community	
	Popular protest online – Internet enables new types of protest	

is seen by many as reinforcing social exclusion, through the operation of the digital divide.

5.1.1. Job creation

The growth rate of jobs in the Information Society in 1999 was approximately 8% in Europe. Each job in the IT industry creates four jobs in the wider European economy, either upstream through suppliers or downstream in service industries which rely on packaged software.[29] New jobs in the ICT sector may have given the individuals concerned an opportunity to participate in and contribute to society.

The overall picture is, however, less rosy. The constant upgrading of skills required in this sector to keep pace with changes in technology favours the highly skilled. As former US Labor Secretary, Robert Reich, argues, "a great premium is placed on people who are innovators and a rapidly decreasing value on people who are in routine production".[30] The rise of the knowledge worker threatens lower skilled workers with marginalisation.

5.1.2. The digital divide

The distribution and use of ICT has been viewed as a means of narrowing the gap between the world's rich and poor. However, the difficulties of establishing universal access could serve to reinforce current patterns of social exclusion.

[29] "Benchmarking Report following-up the "Strategies for Jobs in the Information Society", Commission Staff Working Document, February 2001

[30] Lecture given at the London School of Economics, 14th May 2001

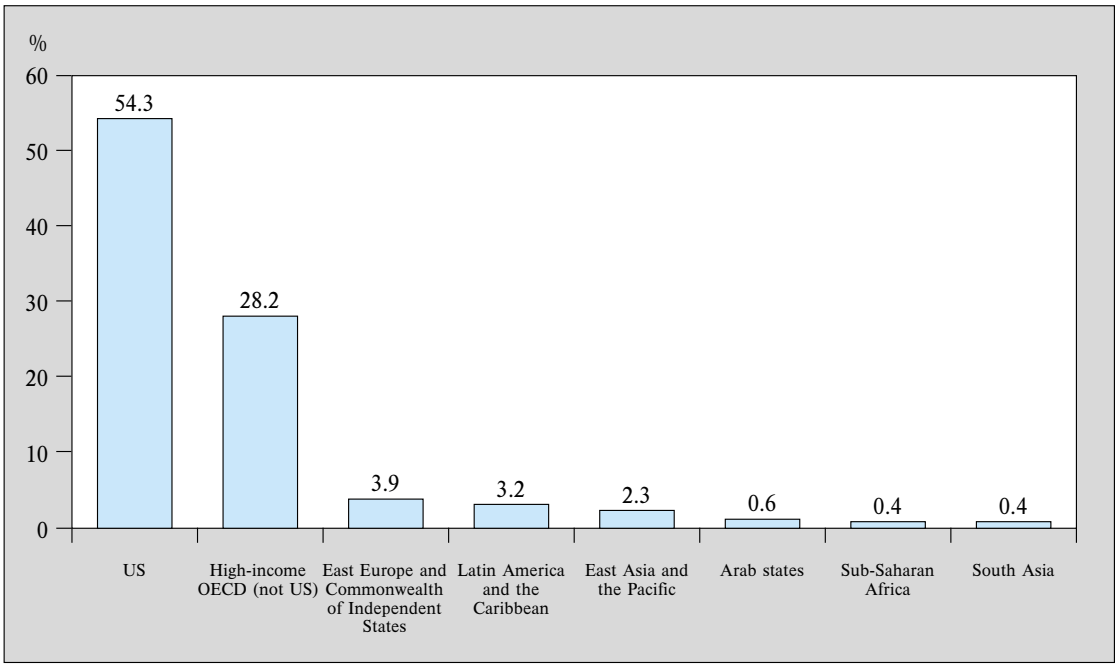


Figure 4
Internet access – % population[33]

Figure 4 shows that Internet access is the preserve of the richest countries in the world and has made very little impact elsewhere. *Table 6* illustrates the scale of difference between European Union countries and some of the poorest countries in the world, in terms of access to telephones. As a general rule, the poorer the country, the less ICT is available.

International initiatives such as the G8's DOT Force[31] are seeking to address the discrepancies. At the same time, some multinational ICT companies are investing huge sums in access for the developing world. An initiative by one ICT equipment manufacturer will see the company sell, lease or donate over € 1 billion worth of its products to developing countries. According to the World Resources Institute's Digital Dividend project, there are significant business opportunities in creating appropriate technologies for use in the developing world.[32]

Discrepancies in access to ICT exist within Europe itself. While 65% of households in Sweden and 60% in the Netherlands have Internet access, the figures for Spain and Greece are only 25% and 10% respectively.[34] Similar differences exist within countries, both between regions and along socio-economic lines. High income earners in the EU enjoy three times higher Internet usage rates than low income earners and traditionally excluded groups such as the elderly and unemployed, have particularly poor access to the Internet.[35]

The European Union's eEurope Action Plan agreed in 2000 focuses heavily on increasing online access by providing a cheaper, faster, more secure Internet, increasing public access points and improving IT skills.[36] Within this frame-

[31] http://www.dotforce.org/

[32] http://www.digitaldividend.org/index.htm

[33] United Nations Human Development Report 2001. Figures for 2000, p. 40

[34] http://europa.eu.int/information_society/eeurope/benchmarking/index_en.htm

[35] "Benchmarking Report following-up the "Strategies for Jobs in the Information Society", Commission Staff Working Document, February 2001

[36] http://europa.eu.int/information_society/eeurope/action_plan/actionplantext/index_en.htm

Table 6
The digital divide – telephone penetration in selected countries[37]

Country	GDP per capita (purchasing power parity US$, 1999)	Telephone mainlines/ 1,000 population (1999)	Cellular mobile subscribers/ 1,000 population (1999)
Luxembourg	42,769	724	487
Ireland	25,918	478	447
Denmark	25,869	685	495
Belgium	25,443	502	314
Austria	225,089	472	514
Netherlands	24,215	606	435
Germany	23,742	588	286
Finland	23,096	552	651
France	22,897	579	364
Sweden	22,636	665	583
Italy	22,172	462	528
UK	22,093	575	463
Spain	18,079	418	312
Portugal	16,064	424	468
Greece	15,414	528	311
Czech Republic	13,018	371	189
Poland	8,450	263	102
Angola	3,179	8	2
Pakistan	1,834	22	2
Bangladesh	1,483	3	1
Yemen	806	17	2
Sudan	664	9	0

Note: These figures do not always correspond with Table 8, *The ICT market in Europe,* and Tables 91 and 93 of the *Statistical outlook.*

[37] Mainline and cellular telephone penetration in selected countries, ranked by UN Human Development Index, see: UN Human Development Report 2001, p. 60

work, member states have pursued various initiatives. For example, the Danish government granted tax exemptions on computers supplied by employers for use by employees at home until January 2001. This scheme has made a significant contribution to the very high penetration of PCs in Denmark.

In order to fully realise the social opportunities of ICT, greater access to high-speed Internet connections is essential. Until large quantities of data can be transmitted quickly at relatively low cost, the development of E-health, E-government and telework will be stifled. It has been argued that effective universal access should be thought of as universal access to broadband infrastructure at home; at the end of 2000, however, only 1.1% of EU households had access to a high-speed ADSL connection.[38]

Because penetration of mobile telephones and interactive digital televisions promises to be higher than PC penetration, these technologies may offer hope for more widespread access to the Internet. There are also those, such as the Intermediate Technology Development Group, that argue that resources might be better devoted to cheaper "low" technology with a proven track record in alleviating poverty.

5.2. Second order impacts and opportunities

According to a positive assessment, the ongoing use and application of ICT presents numerous opportunities for society: improved work-life balance, greater access to information and better services. But the full realisation of the second order potential of ICT is still someway off. Barriers such as lack of access, inadequate security and low levels of trust stand in the way of the majority benefiting from these opportunities.

5.2.1. Access to information

With fewer resources required to publish and disseminate information on the Internet compared to any offline medium, the amount of information freely circulating online is constantly growing. Information can be disseminated so rapidly that government, business and professional bodies can no longer act as gatekeepers to information as they traditionally have. This presents a tremendous opportunity. However, sifting what is of use from what is available can be a difficult task: the Internet provides no guarantee of quality or accuracy.

i. Access to health information

Health-related information online comes from a range of sources, from patients to for-profit companies and the public sector. At best, it allows individuals to take greater responsibility for their own health, promoting individual well-being and ideally reducing pressure on public health services. This is the thinking behind NHS Direct,[39] a public sector health portal introduced by the UK government. Equally, the Internet offers access to a broader range of health-related information than conventional medicine, promoting individual choice. Even the latest medical research is publicly available through online medical journals, such as the US National Library of Medicine's MEDLINE.

However, the vast amount of information online can often be difficult to navigate and sort, and in many cases no systems to guarantee accuracy or lack of bias are in place. In the context of healthcare, misinformation can be particularly dangerous. A public system or system of third party verification may alleviate this problem, but healthcare professionals disagree over the extent to which self-diagnosis and treatment should be encouraged. The potential for serious oversight or misdiagnosis is all too apparent.

[38] Damian Tambini, IPPR/-Citizens Online, "Universal Internet Access", November 2000

[39] http://www.nhsdirect.nhs.uk/

ii. Access to government information

The eEurope Action Plan[40] aims to create a socially inclusive knowledge economy in Europe. It set 2002 as the target date for all government information to be available online, on the basis that easy access to public service information can play a significant role in promoting social inclusion.

Online government information can play a broader role in increasing government transparency and accountability towards its citizens. This is potentially significant in boosting government legitimacy at a time when voter turn-out in elections is decreasing.

However, those most in danger of social exclusion, such as the elderly or unemployed, are also those least likely to have access to the Internet. This is not adequately mitigated by the provision of public access terminals. The success of "E-government" is dependent on participation by citizens and at present only around 50% of Internet users in the EU have accessed government information online.[41]

5.2.2. Security challenges

Trust must underpin all transactions – financial and social – if the Internet is to operate efficiently and bring benefits to society. However, as a recent survey suggests, E-commerce is being stifled by concern over Internet security.[42] With significant amounts of personal information entered online, including financial information, privacy and security have become a priority.

The Internet is also the perfect tool for criminal groups such as child pornographers and terrorists, to organise globally. There is clearly a conflict between protecting the privacy and security of legitimate users of the Internet, and regulating the Internet to prevent abuse: there are concerns that regulation of the Internet will undermine the medium's strengths of freedom and flexibility. Furthermore, it is as yet unclear where responsibility for content on the Web lies, as the recent controversy in France over the sale of Nazi memorabilia showed.

Business has taken an active stance in response to abuse of the Internet. Some Internet service providers have restricted the type of content which can be accessed through their search engines.

5.2.3. Access to better services

i. Health

Surgeons directing operations via remote online access may make the headlines, but the range of possibilities for using ICT to improve healthcare services is much broader. Fully searchable online medical records, Web-linked health call centres, online patient monitoring and remote consultations could provide patients with a better, more efficient healthcare system. At the same time, online monitoring and consultation may improve quality of life if patients can be treated at home rather than in hospital. The ability of ICT to overcome distance means that E-health services offer specialist healthcare to those in remote locations, as well as to excluded groups such as prisoners.

The barriers to rolling out ICT in healthcare beyond individual initiatives are significant. As with so many applications of ICT, telemedicine depends on inclusive access to high bandwidth, reliability and security.[43]

[40] For more information please see EITO 2002, Part Two: "E-government and the business environment"

[41] Benchmarking Report following-up the "Strategies for Jobs in the Information Society", Commission Staff Working Document, February 2001

[42] Survey commissioned by Confederation of British Industry, in Financial Times, 31st August 2001

[43] "E-Life or E-death? A White Paper on the Social Implications of Cyber Medicine", Peter James and Peter Hopkinson, Sustain IT, August 2000

Online healthcare around the world

Australia is the current world leader in online healthcare. It has developed centralised databases of medical records, online health information and support, and its Hospitals Without Walls project aims to find ways of treating and monitoring patients at home.

The US is pioneering several telemedicine projects, such as a telehospice project in Kansas which uses phone lines and set-top boxes to provide care and support to patients.

The UK government has developed the NHS Direct Website which integrates online information and a health call centre.

ii. Education

The growing body of education and learning resources available online offers flexible, individually-tailored learning solutions which facilitate lifelong learning. Some of the world's leading universities, such as MIT, now offer courses and course content online, free of charge. In the UK, a national E-University will from 2002 offer 84 courses from some of the country's leading institutions. Lifelong learning has become a key European policy goal in developing the new "knowledge-based economy", but again if this is to be delivered via the Internet, the crucial question of universal connectivity must be answered.

iii. Government

The impact of ICT on government services[44] is two-fold. Behind the scenes, information technology allows for significant levels of integration and co-ordination in administration, contributing to greater efficiency in the delivery of public services. This is particularly the case where the services required are split across government departments.

At the same time, online public services are more easily accessible. In Singapore a single portal offers access to all services from the cradle to the grave. In Europe, fully online services have been slow to develop, with online interaction largely confined to tax and cultural services.[45] There is a need to develop government sites organised in a way which responds to the requirements of citizens and business rather than following administrative structures. In doing so, government will be able to increase legitimacy amongst its citizens.

5.2.4. E-commerce

B2C online retail could help to improve work-life balance by freeing up some of the time currently spent by consumers on retail activities. However, it is still far from certain that E-commerce will be adopted en masse by European consumers.

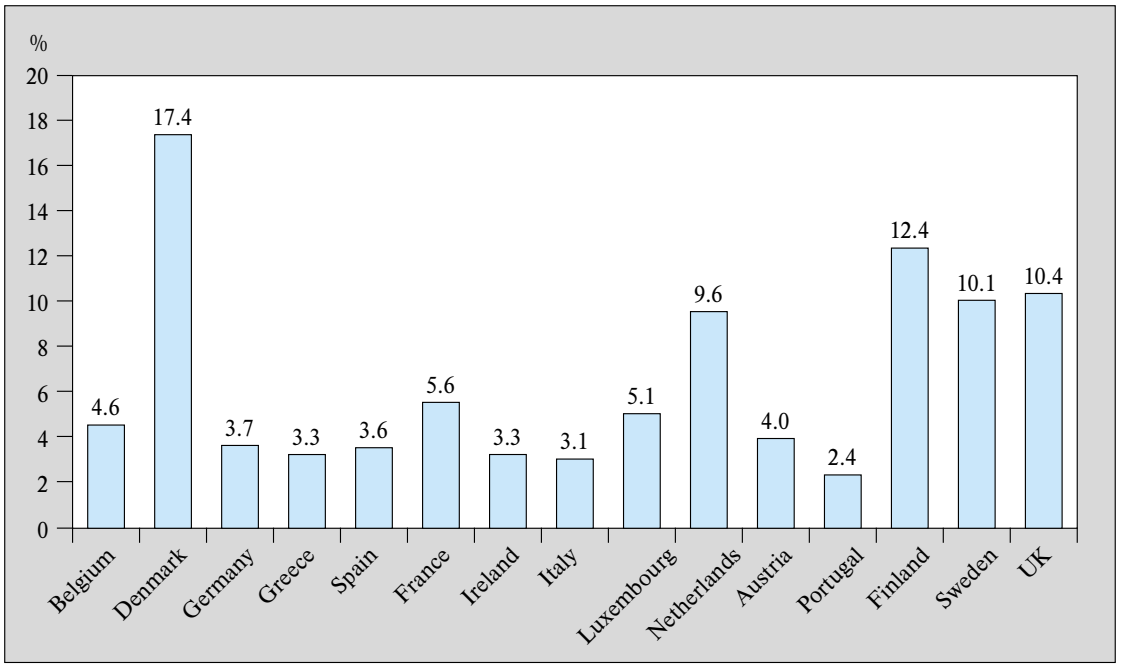
Again, the opportunities of E-commerce depend on widespread connectivity. Additionally in this case, participation often relies on possession of a credit or debit card, which excludes a significant proportion of Europe's population. In view of this, alternative means of online payment are being developed. Electronic purses and smart cards for example use software which stores currency and can be built into a mobile phone, PC or digital television.

For those who are unable to take advantage of online services, the closure of high-street branches only serves to further exclude them from opportunities for full participation in society.

[44] For more information please see EITO 2002, Part Two: "E-government and the business environment"

[45] Benchmarking Report following-up the "Strategies for Jobs in the Information Society", Commission Staff Working Document, February 2001

Figure 5
Proportion of employed people engaging in telework[47]



5.2.5. Telework

At present 5.6% of workers in the EU telework.[46] Denmark leads the way with 17.4% of workers regularly or occasionally teleworking (see *Figure 5*). Teleworking among managers is more common: 42.2% of managers in Denmark and 26.7% in the UK telework.

There are numerous social benefits of telework, for example:

- less time spent travelling to work;
- greater flexibility with working hours;
- more time spent with family;
- inclusion in the workforce of hitherto excluded groups such as the physically disabled, carers and parents with young children;
- improved opportunities for work in remote areas.

On the negative side, rather than being liberating, the removal of the workplace community can undermine employee morale. The creation of telecottages and telecentres may respond to the need for social interaction. One company has created seven telecentres in the Parisian suburbs close to where employees live, so that social contact can be maintained without entirely compromising flexibility.[48]

Pay and working conditions can be worse for some teleworkers: Europe has over one million people (growing to 2.5 million by 2006)[49] doing repetitive teleworking jobs such as data-entry, copy-typing and telesales, on less pay than their non-teleworking counterparts. Denmark and Ireland are currently the only two countries in Europe with codes of practice covering teleworkers. The European Trades Union Congress

[46] Benchmarking Report following-up the "Strategies for Jobs in the Information Society", Commission Staff Working Document, February 2001

[47] Eurobarometer survey on e-work, November 2000. Telework is defined as "carrying out all or part of their work away from their normal places of activity, usually from home, using ICT".

[48] e-work 2001, Information Society Technologies, September 2001

[49] e-work 2001, Information Society Technologies, September 2001

and the employers' organisation UNICE (Union of Industrial and Employers Confederations of Europe) are negotiating an agreement to cover health and safety, work organisation and union protection for teleworkers.

5.2.6. New communities online

The Internet was created as a tool to allow university researchers to collaborate across geographical barriers. Its disregard for physical distance has resulted in the formation of new communities online. Some of the earliest online communities were formed as support and information groups by mutual sufferers of illness and their carers, as a complement to conventional support structures. Other examples are the anti-globalisation movement, the community of Star Trek fans or the community of programmers who form the Open Source movement.

These online communities tend to bolster offline community rather than replace it. Geographic communities are not being replaced by "E-tribes" as was once thought possible.

5.2.7. Popular protest online

In addition to enabling the formation of new, global communities, the Internet also gives easy access to an unprecedented amount of information about companies and governments. This information can then be used in political campaigns online and offline.

- One example of online action is the emergence of spoof company Websites such as mcspotlight.com and shameonnike.com.
- Motivated protestors have attacked companies through their Websites using hacker skills, bringing down computer systems and Websites.
- Malcontents send E-mails in large numbers to protest against unpopular policies. When George Bush withdrew the US from the Kyoto Protocol, protest E-mails from environmental campaigners worldwide brought down the White House Website.
- Street protests, for example at the WTO meeting in Seattle, are often organised over the Internet.

5.3. Third order impacts and opportunities

Isolating the aggregated effects of large scale ICT use on society and social equity, from equivalent effects on the economy or the environment, presents many challenges. Equally, society is effected by a vast range of other factors, and at this level it is artificial to separate these from those of ICT use. However, there follow a number of opportunities for building social capital, to which widespread adoption of ICT has contributed.

5.3.1. Cultural homogeneity or cultural diversity?

Despite the creation of software and interfaces that support languages with non-Roman scripts such as Arabic and Japanese, the majority of information on the Internet is in English and originates from the US. ICT is accelerating a trend which is a symptom of globalisation more widely. However, the detrimental impact on linguistic and cultural diversity is as yet un-

known. If English comes to dominate almost exclusively, the potential for non-English speakers to be marginalised in the knowledge economy would be a serious concern.

Counter trends exist though. There are opportunities for new types of cultural diversity in cyberspace. What is more, the Internet can be used to bolster cultures and communities under pressure. For example, Cornish is a language spoken by just a few thousand people worldwide, but the online community of Cornish speakers has a daily global newspaper, in the form of Nowodhow Kernow.[50]

5.3.2. Building local communities

The widespread adoption of ICT into society may make it possible to rebuild strong local communities, where these have been eroded. E-commerce and telework both may reduce car travel and provide an incentive for people to spend more time with their families and in their local geographical community. The incentive will be enhanced if local amenities such as post offices or corner shops act as E-commerce delivery points. Local businesses would also benefit.

Research has shown that interaction over the Internet actually encourages interaction offline. If Web traffic can be directed into localities, this could encourage local face-to-face interaction and revitalise communities.

5.3.3. Building civic culture

The Internet may offer a way of channelling popular interest in political issues back into the formal political process. Online voting is one means. In the Kalix municipality in Sweden, the local authority sought the opinions of local residents via an online consultation prior to drawing up plans for redeveloping the town centre.[51]

The Internet can allow citizens to engage directly in the political process. Online inputs into formal decision-making processes, online consultations and online advocacy can increase participation. Similarly, ICT gives political parties a means of reaching new audiences faster and with fewer resources than with door-to-door canvassing. Mass communications are essential for building coalitions of support in an age when party affiliations are weak and swing voters make the difference. However, if ICT is to reinvigorate the democratic process, access itself must first be democratised.

[50] http://www.geocities.com/cornishnews/

[51] http://www.votia.com

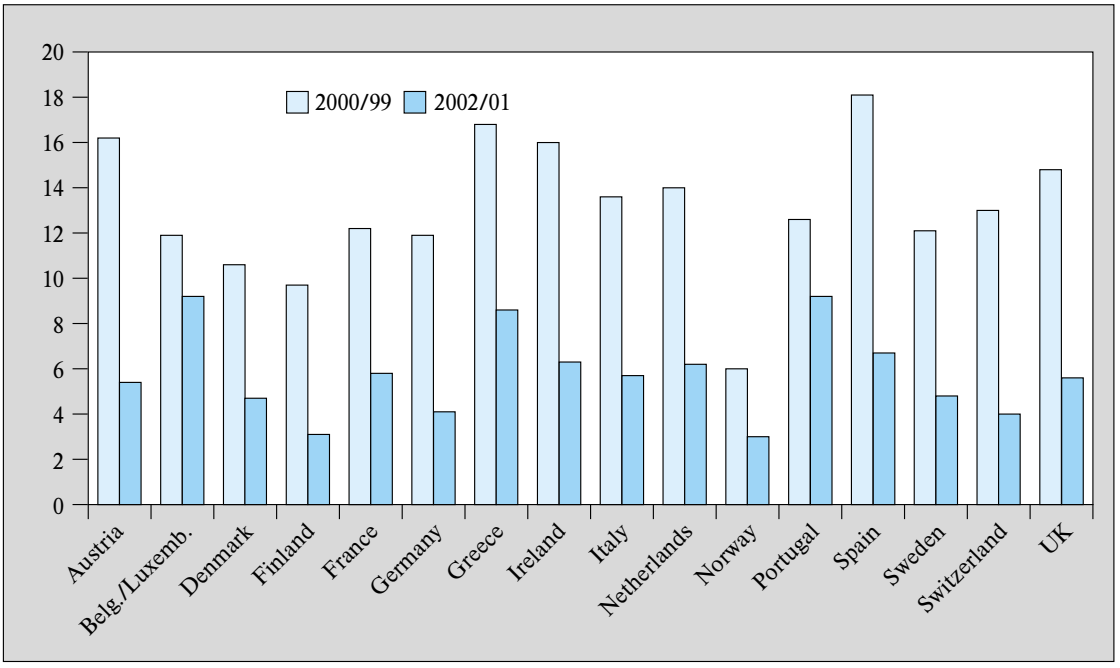
6. Economic sustainability and ICT

Table 7 summarises the economic impacts and opportunities created by ICT.

First order effects	Second order effects	Third order effects
Growth of the ICT market – Size of sector and numbers employed	**Application of ICT within businesses** – ICT creates opportunities for new efficiencies in business	**ICT and the "new economy": a new paradigm of growth?** – Long-term and fundamental changes to the global economy may create a more beneficial environment for the goals of sustainable development
Ongoing investment in ICT – Investment in technology within companies continues to grow	**New opportunities for SMEs** – New markets and more efficient production for SMEs	**Exclusion or inclusion?** – The globalised economy may reinforce uneven patterns of wealth – ICT may provide new solutions to ensure economic benefits are shared
Ongoing investment in ICT research and development – Resources continue to be ploughed into developing new technologies	**Financial markets** – ICT enables new financial markets, creating growth – ICT enables wider participation in financial markets	
New types of company – Changing the structure of the economy	**The relationship between business and the market** – Consumers are empowered – Companies are encouraged to act ethically	
Boom and bust – Market volatility		

Table 7
Economic sustainability and ICT

Figure 6
ICT growth rates in Western Europe in %[52]



6.1. What is economic sustainability?

Economic sustainability could be taken to mean the conditions whereby stable economic growth can be sustained long term. This is certainly important, but is only part of the picture. The aims of sustainable development are to create growth that is socially and environmentally beneficial. It should balance out social inequalities and create opportunities for all, while not depleting the Earth's resources any further. Instead growth should invest in the rebuilding of ecosystems to provide for the long-term prosperity of humanity as a whole.

Economic growth in the context of sustainability is therefore best understood as socially and environmentally sustainable economic growth: growth that is measured by its contribution to improvement in human welfare.

6.2. First order impacts and opportunities

6.2.1. Growth of the ICT market

ICT has an increasingly significant role in the European economy, making the social and environmental impacts and opportunities outlined in this section all the more important.

The ICT market is expanding across Europe and looks set to continue in the future despite the slowdown in late 2000–2001. Year-on-year growth of the ICT market in Western Europe was 13% from 1999–2000 and is expected to be 5% from 2001–2002,[53] well above average GDP growth in the same period (see *Figure 6*).

This growth is reflected in the increasing number of people employed in the sector. In Finland for example, ICT employment increased by an average of 8% per annum between 1995 and 1999 and stood at 1,292,000 in

[52] EITO 2002, *Table 11,* Statistical outlook

[53] EITO 2002, *Table 12,* Statistical outlook

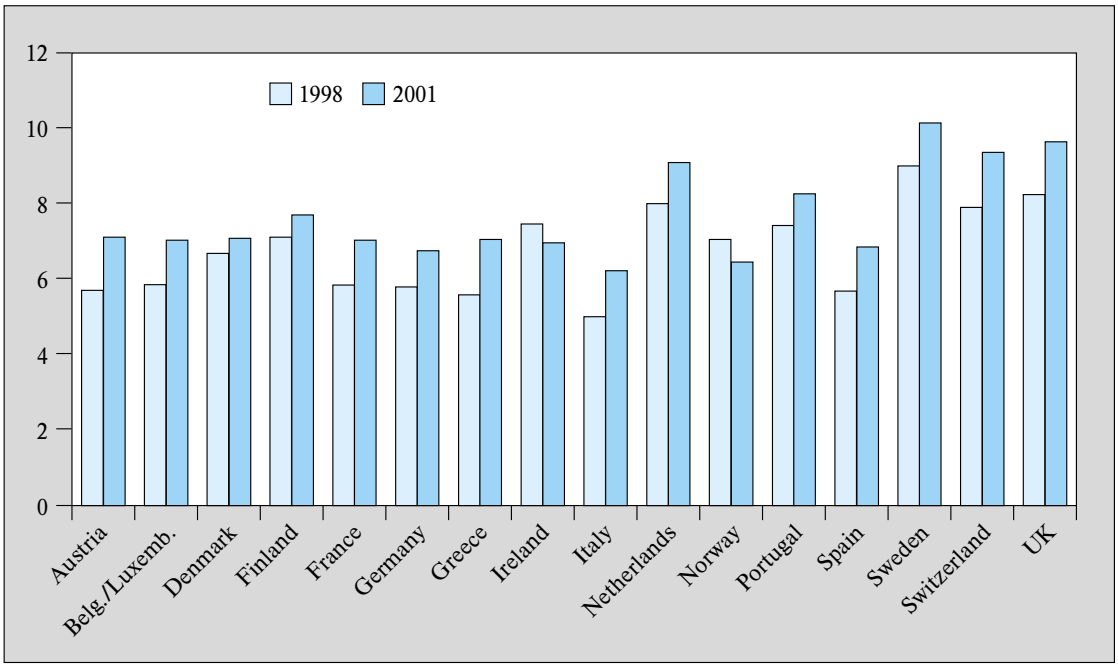


Figure 7
ICT expenditure as a percentage of GDP[54]

1999. Employment growth in OECD countries was on average 12% in the ICT sector in the four-year period from 1995 to 1999.[55] Employment growth exists not only in the first order design, manufacture and disposal of ICT equipment, but also in its application through ICT service providers, software manufacturers and more widely in economies as a whole through the stimulation of economic growth.

6.2.2. Ongoing investment in ICT

The increasing importance of ICT in the economy is demonstrated by the continued heavy investment into ICT made by business, finance, government and every type of institution. ICT capability is regarded as an essential prerequisite for operation in the modern economy and society. Continued investment into ICT equipment drives the move to a more ICT dependent economy, in which sustainable development issues can better be addressed.

Figure 7 illustrates that the share of GDP spent on ICT increased significantly since 1998 in most countries.

6.2.3. Ongoing investment in ICT research and development

ICT companies and research institutions continue to plough large amounts of capital into their research and development budgets. In the period 1990–1997 applications to the European Patent Office for ICT patents increased by 8% per annum, compared with 5.7% per annum for all patents.[56] The ongoing development of new technologies has direct benefits for the companies responsible, but also has wider benefits for the economy and society as a whole. Studies suggest that the social return of research and development is at least twice as big as the private return due to spillover benefits to other firms.[57]

[54] EITO 2002, *Table 88,* Statistical outlook

[55] Groningen Growth and Development Centre, http://www.eco.rug.nl/ggdc/ictdatabase.html

[56] OECD STI scoreboard

[57] Economist, 23 September 2000, p. 43

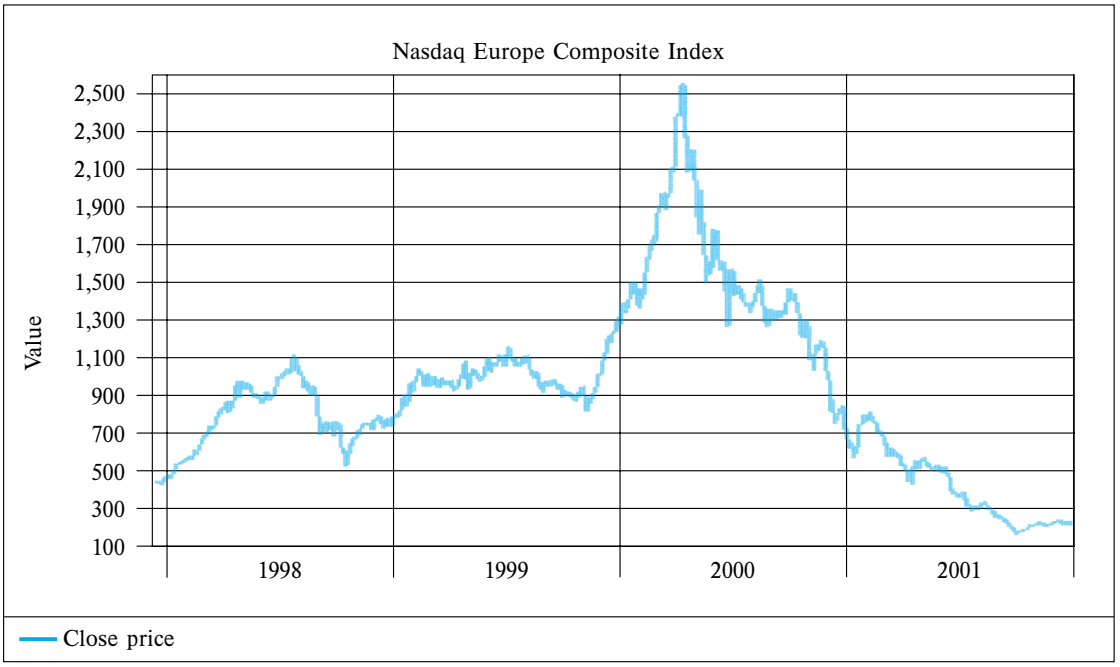


Figure 8
Boom and bust in the ICT sector – Nasdaq Europe Composite Index[58]

6.2.4. New types of company

The rapid development of ICT has led to the creation of a range of new types of company to produce the infrastructure and provide the necessary support services:

- Completely new markets have developed, such as the mobile telecommunications or the optical fibre market.
- Certain characteristics of ICT implementation and management – for example the tendency for new waves of functionality to appear with relative speed, or the specialist knowledge required for programming – have led many companies, especially SMEs, to outsource their ICT needs. This has encouraged the development of specialist support agencies looking after core business activities such as Knowledge Management, Website design and hosting or Customer Relationship Management.
- Specialised software requirements are also outsourced. Instead of using expensive and quickly outmoded custom-built software solutions, many companies employ Application Service Providers (ASPs) to modify and implement off-the-shelf solutions for Supply Chain Management or manufacturing processes.

This has inevitably led to diversification in economies and new opportunities for employment.

6.2.5. Boom and bust in the ICT sector

The dramatic inflation and collapse of the "dot.com bubble" has attracted much media attention. Much larger organisations in the ICT sector than dot.com start-ups have been affected by the downturn in technology stocks. *Figure 8* shows how ICT stocks in Europe have changed in value from 1998–2001. The Nasdaq Europe index includes a wide range of ICT companies of different type and size.

[58] Nasdaq Europe: http://www.nasdaqeurope.com/ [with permission]

Clearly there are a range of factors that have contributed to the boom and bust of technology stocks. In the context of sustainable development, it is worth asking whether the nature of ICT in the economy, requiring rapid development and deployment, encourages market volatility.

6.3. Second order impacts and opportunities

6.3.1. Application of ICT within businesses

ICT has had a profound effect on the efficiency of internal business systems. To take one example, ICT has had particularly beneficial effects on businesses' inventory management, with implications for economic stability. ICT has increased the quality and speed of information that companies receive, for example through bar-coding and real-time transmission of sales data. Computer Aided Design has also meant that set-up and production lead times have been reduced. Companies are able to operate with lower inventories and suppliers can produce more to demand, reducing risk and ultimately volatility. The inventories of durable consumer goods for example fell relative to sales by approximately 20% between 1988 and 2000.

The application of Web-managed control software can result in:

- faster production lines and faster turnover;
- better logistics, cost and quality control;
- more information and better communication throughout a business;
- substantial elimination of waste.

The economic savings thus created also represent in many cases environmental savings.

6.3.2. New opportunities for SMEs

Larger companies have had access to global markets and economies of scale for a long time but these opportunities are now becoming available to smaller companies through the application of ICT.

- SMEs have access to new consumer markets through the development of B2C E-tailing sites. B2B E-commerce provides greater exposure to business with large organisations using E-procurement policies or whole markets where E-marketplaces operate. This can provide small companies with limited resources access to global markets at very low cost.
- A more networked economy creates greater economic diversity. SMEs are ideally placed to take advantage of developing market niche products and services.
- SMEs have hitherto lacked the ability to exploit efficiencies through large scale production. However, ICT control systems are as applicable to small companies as they are to large and can allow SMEs to compete on price.

The boost to SMEs has the potential to stimulate local economies and foster regional development, contributing to a more equitable distribution of wealth and opportunities, a key element of a more sustainable society and economy.

6.3.3. Financial markets

The application of ICT has been closely linked to the rapid expansion of the world's financial markets in the past ten years.

- ICT is used to communicate the data on which the operation of financial markets is based. With the development of much faster and more powerful ICT, financial markets around the world have been able to grow and develop links. Because these financial

markets deal exclusively in intangibles, there is no limit to the speed and volume of financial transactions.

- New financial sectors such as futures, derivatives or spread betting have been catalysed by ICT as it enables highly complex mathematical calculations and practically instantaneous transfer of data.
- ICT has opened up financial markets to wider participation. Through online shares trading sites, financial information is disseminated to a new global community of individual shares traders.

The inclusion of large numbers of individual investors in the financial markets is at first glance a positive democratising development. It may however lead to an increase in market volatility, as individual investors operate according to different rules from those of corporate investors and their vast electronic markets.

The success of the financial markets generates global wealth which can be channelled to address social and environmental issues. However, it has been argued by some observers that the market is difficult to predict and regulate and creates patterns of wealth that are not globally inclusive.

In the overwhelming majority of cases, investment decisions are made taking only economic factors into consideration. If social and environmental performance of companies can be given a market value, the financial markets have great potential to contribute to sustainable development.

6.3.4. The relationship between business and the market

ICT has changed the way that business connects to its markets in several ways. For example, ICT has stimulated the development of new business models such as E-marketplaces and has enabled individually-tailored marketing strategies and product supply. Of particular importance for sustainable development, ICT has provided the means for greater empowerment of consumers, and has gone some way to enabling greater corporate accountability.

i. Empowerment of consumers

Increased product information online allows consumers to make informed purchasing decisions more easily. The growing body of ethical and green consumers is better placed online to make well informed purchasing decisions. For example, www.mtprog.com rates household appliances based on environmental criteria. At the same time, E-commerce is better suited to niche markets as niche consumer groups are more easily targeted online than offline through expensive marketing campaigns.

ii. Corporate accountability

Corporate information is now more widely accessible than ever before, over the Internet. This enables consumers – indeed all stakeholders – to scrutinise companies' social and environmental records, and then take action if they feel a company is operating unethically. For example, the Internet was key to organising the popular movement against use of child labour in supply chains.

Furthermore, it has been argued that economic relationships online, in an environment where face-to-face contact is rare, place a greater emphasis on trust. If a company can be seen as socially responsible, it is also seen as trustworthy, and so attracts business, investment and new recruits.

In these ways, the increasing use of the Internet has been one factor stimulating companies to develop strategies for Corporate Social Responsibility (CSR). Many companies have CSR departments and are committed to reporting on social and environmental as well as economic performance.

"The Cluetrain Manifesto" examines how the Internet has been central to the restructuring of business. Its authors argue that the Internet has been responsible for changing the balance of power between companies and consumers, in favour of the latter. According to them, the Internet makes new relationships possible, "humanises the corporation, emphasises its interactions with other stakeholders and so reinforces its social and environmental responsibilities".[59]

6.4. Third order impacts and opportunities

6.4.1. ICT and the "new economy": a new paradigm of growth?

Undoubtedly, today's developed-world economy has some different characteristics to that of twenty years ago. For example, production of material goods has given way to a focus on services. Thus, the number of service industry jobs in France as a proportion of total employment rose steadily over the past century, from approximately 25% in 1900 to over 70% in 1990. Globalisation is also a feature of the modern economy, reflected in the increasing number and influence of multinational enterprises and global trade bodies.

The increasing penetration of ICT has a very significant role to play in these changes to the modern economy, enabling services to be delivered efficiently and providing the means to bind the global economy together.

Whether these changes constitute a "new economy", a paradigm shift in the fundamentals of economics, or whether they are the culmination of long-term trends, is a matter for debate.[60] More importantly, the modern economy that is emerging, with ICT at its core, may be beneficial to the goals of sustainable development.

Central to this claim is the possibility that ICT contributes to generally higher rates of productivity growth. In the years 1972–1995, for example, productivity in the US economy grew by 1.4% per annum. This figure increased to 2.5% per annum between 1995 and 2000, at a time when growth in ICT use was evident.

The IMF has identified this increase in US labour productivity with ICT-related capital deepening and ICT-related efficiencies.[61] The US Department of Commerce calculated that in 1997 and 1998, when the US economy grew by 8%, between 27% and 28% of that growth was attributable to the growth of ICT. Romano Prodi, President of the European Commission, said of US growth that it "leaves no doubt as to the potential benefits of the new economy in terms of growth, employment and low inflation".[62]

However, dissenting voices exist. A recent report suggested that US growth in the period 1995–2000 was concentrated in just a few sectors of the economy, and not across all sectors as would have been expected had ICT been the driving force for growth.[63]

Furthermore, similar patterns of productivity growth have not as yet been replicated in many other developed economies, such as Finland or Sweden where ICT use is as high or higher than in the USA. Nor is there clear evidence connecting ICT use and productivity growth in these countries.

[59] Rick Levine et al., "The Cluetrain Manifesto: The end of business as usual", 2000

[60] See for example "Is there a new economy? First report on the OECD growth project", OECD 2000

[61] IMF, "The Information technology Revolution", 2001 – see http://www.imf.org/external/pubs/ft/weo/2001/02/

[62] Conference report from "The e-economy in Europe: its potential impact on EU enterprises and policies", 2001

[63] Financial Times, 17 October 2001

If ICT does indeed drive productivity growth, the increasing penetration of ICT systems and applications across all aspects of human endeavour may provide for greater prosperity and stability in the economy of the future. It may even be possible for economic growth to finally be de-coupled from growth in consumption and resource use, as explored earlier,[64] creating a context in which the goals of sustainable development can more easily be achieved.

6.4.2. Exclusion or inclusion?

There are signs that the embedding of ICT in the new economy does not in itself address differences between the rich and poor. The richest 20% of the world's population still accounts for 86% of GNP, 74% of telephone lines and 93% of the world's usage of the Internet.

Some economists argue that the global economy, driven by the financial markets, seeks value and bypasses areas where little profit can be made, creating a substantial minority of economically excluded people living in developing countries and parts of developed countries alike.

It has been shown that uneven distribution of ICT around the world leads to the creation of a digital divide. However, the rapid development of ICT may present the opportunity for countries currently with poor ICT infrastructure to "leapfrog" old economy solutions and proceed directly to those of the new economy. For example, Rwanda is looking to roll out a mobile telecommunications network without ever having invested significantly in fixed line. Similarly, emerging markets in the east of Europe such as Poland will soon have a much higher penetration of mobile phones than of fixed-line phones. There are also many attempts to use fixed-line Internet access in developing and emerging economies to distribute economic benefits more evenly.

[64] See section 4.3.

7. Evaluation

This paper has reviewed the impacts and opportunities of ICT on the three spheres of sustainability: environmental, social and economic. In evaluating the overall picture, it is necessary to draw these three spheres together and identify where the balance of positive and negative effects lies.

Figure 9 summarises the balance of positive and negative impacts and opportunities of ICT on sustainable development, as presented in this chapter.

7.1. First order impacts and opportunities

The impetus for the development of ICT has been primarily economic, and so the immediate effects of ICT on economic sustainability are expected to be positive (*c* in *Figure 9*). This is the case, despite the current depressed state of the ICT sector. Indeed, it has been argued that the bubble that burst in 2000 was a financial bubble and not a technology bubble: technology stocks were overvalued, but confidence in the technology itself remains strong.

The immediate effects on the environment are quite the opposite (*a* in *Figure 9*). Production of ICT equipment does not place the same level of demands on natural resources, nor is it as polluting, as many other industries, but nonetheless the manufacture, operation and disposal of ICT equipment all have negative environmental impacts. Although efforts are being made to mitigate these effects from within the ICT industry, action is also required at a policy level:

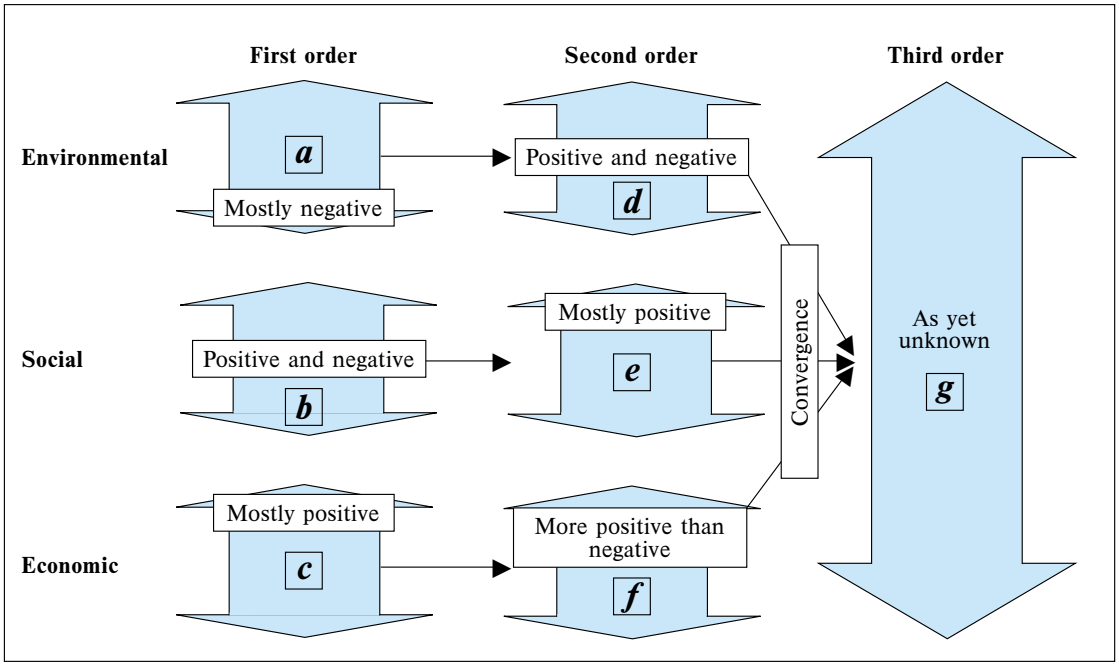


Figure 9
Evaluating the effects of ICT on sustainable development

- to attain greater environmental efficiency in production;
- to produce greater environmental efficiency of the equipment itself and
- to encourage "design for the environment" making equipment suitable for recovery and recycling schemes.

Socially, the effects of ICT manufacture and operation are more balanced (*b* in *Figure 9*). The creation of jobs is of social benefit, just as access to empowering technologies is of benefit to the sections of society that have that privilege. However, patterns of digital exclusion threaten to reinforce patterns of social exclusion, presenting a challenge to policy makers, NGOs and business.

7.2. Second order impacts and opportunities

As *Figure 9* shows, there is greater complexity when considering the effects of the application of ICT on the sustainable development agenda.

Again, as might be expected, ICT applications present opportunities for economic development (*f* in *Figure 9*). Furthermore, there are signs that ICT, in particular through the use of the Internet, empowers consumers with greater choice.

ICT co-ordinated financial markets may create market volatility and exacerbate exclusion, but this may be changing with investors and fund managers beginning to respond to consumer concerns. Indeed, the markets may become a powerful force for sustainable development in the future by directing increasing volumes of capital into companies that can demonstrate a commitment to ethical issues and a practical approach to social and environmental risk management.

Telematics is a promising technology for reducing traffic levels (*d* in *Figure 9*). ICT streamlines business systems, increasing efficiency and therefore decreasing the environmental footprint of business. E-commerce and telework may or may not cause a decrease in the use of transport and a consequent decrease in vehicle emissions, depending on how consumer habits are effected and how support systems are structured. Many of the effects of ICT application on the environment remain in the balance, and it is here that policy initiatives are perhaps most needed to ensure that they are swung in the right direction for sustainability.

ICT applications, in particular the Internet, provide access to information and services and create the possibility for greater community involvement for hitherto excluded groups (*e* in *Figure 9*). Workers may benefit from an improved work-life balance. The Internet may have a generally humanising effect on people's lives. However, the social benefits of ICT at this level are dependent on universal connectivity, widespread "IT literacy" and the relevant content being developed to serve communities and individuals. There is a very significant role for policy makers to play in creating such an environment.

7.3. Third order impacts and opportunities

The aggregated effects of widespread use of ICT throughout the economy and society are as yet ambiguous (*g* in *Figure 9*). Long-term environmental effects are dependent on the type of economy that results from ICT penetration. A "lightweight" economy where intangible goods are valued above material production, where economic growth is de-coupled from growth in energy consumption and pollution, may be emerging. This is the type of economy that would benefit the aims of sustainable development, but it is far from clear whether the economy of Europe is developing in this direction.

Similarly, it remains to be seen whether ICT penetration produces cultural homogeneity or diversity, whether social equity will be boosted or communities eroded. The third order effects on society, as with the economy and the environment, will be unveiled in the long term. Even then, directly attributing macro-level economic social and environmental developments to the increasing use of ICT, rather than to other trends such as the rise of the service economy or changes in cultural attitudes, will be extremely complex.

7.4. Summary

The past twenty years or so have seen ICT become ever more central to the world's economy and culture. This technological revolution is of great significance for several reasons:

- The speed with which ICT has penetrated society is unprecedented by any other technology.
- ICT has an enormous range of applications and can be profoundly enabling.
- The creation of ICT requires less resource than the creation of many other enabling technologies, such as the internal combustion engine, and has very low marginal costs.

In some cases ICT is of direct benefit to the goals of sustainable development; in others ICT is directly or indirectly detrimental to social and environmental concerns. In most cases, however, the effects will only become clear in the medium-to-long term.

The goals of sustainable development are to enable all people to realise their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life-support systems. As these goals become increasingly accepted, more and more facets of human activity will be analysed in terms of their effects on sustainable development.

In the case of ICT, examples of this process taking place have already been observed. However, this section has shown that despite all the potential, there is no overwhelming dynamic in the penetration of ICT that automatically propels the globe towards a sustainable state. Rather, ICT presents an array of opportunities to be taken: ICT is a tool that can be used to steer society in a beneficial direction.

The possibilities of ICT should perhaps be seen as a challenge for those who wish to improve the quality of life for all. The response of policy makers in government, business and in civil society is therefore crucial.

8. Policies and targets

The evaluation of the economic, environmental and social impacts of ICT highlights a series of critical junctures at which action on the part of business and government is necessary if some of the more negative impacts of ICT are to be avoided and the positive opportunities are to be exploited fully. Current trends indicate that there is no room for complacency about the inevitability of positive outcomes.

Although the deployment of ICT through the economy and society is still at an early stage, now is the right time for concerted policy action. In this way, it may be possible to introduce sustainability into the ICT sector from the outset, rather than having to retro-fit social and environmental concerns in response to stakeholder pressure.

Three broad principles should govern any attempts to maximise the synergies between sustainable development and ICT:

- Institutional innovation must be as radical as technological innovation in order to keep up with the pace of change.
- Business, government and non-governmental organisations (NGOs) must work in partnership for action to be effective.
- Successful policy will depend on a longer term view, beyond the ups and downs of ICT stocks prices.

8.1. A selection of policy options

There is a range of policy tools available to government and business in attempting to influence the development of ICTs and their impacts. Maximising the potential of ICTs to promote sustainable development will depend on how these policy tools are implemented and the degree of co-ordination between different levels of government, business and other policy actors such as NGOs.

Table 8 sets out a selection of policy tools which could be used, together with a brief explanation of how each tool functions and an indication of where each can be most effective. In addition, it offers specific examples for each policy tool within the framework of ICTs and sustainable development.

Table 8
Policy options

Policy tool	Explanation	Primary focus	Policy examples
Frameworks	A broad statement of goals and strategy which establishes the direction for more specific policy measures.	The opportunity to affect development at the first, second and third orders by changing strategic lines of thinking and creating a fertile environment for new policy initiatives.	The EU could take a lead in creating an integrated framework for eEurope and sustainable development. This would create a favourable environment for new policy initiatives and legislation to promote the positive impact of ICTs on sustainable development.
Market-based policies	Market-based policies, such as fiscal instruments, offer a way of promoting social and environmental concerns by reallocating the burden of taxation. At the same time, they promote innovation and stimulate new markets.	Market-based policies may create incentives to reduce negative first and second order environmental and social impacts, whilst promoting a dynamic, competitive ICT sector in Europe.	Tax exemptions could be offered to employers purchasing computers for use by employees at home. This would promote digital inclusion as well as creating opportunities for home working to reduce commuting and office space. Increased taxation on high-emission fuels could shift usage towards renewables and stimulate innovation in new fuel technologies. This could reduce the home delivery impacts of E-commerce.
Regulation	Public authorities mandate the social and environmental standards to be achieved, or the technologies to be used, by firms.	Regulation can reduce negative first order environmental and social impacts. However, regulation offers less flexibility than market-based incentives and so market-based incentives should be favoured where possible.	The EU draft directive on universal access could be extended to broadband by 2015 to promote digital inclusion. Member State governments could increase fines for heavy-metal contamination in order to encourage industry to replace toxic substances in production.
Voluntary industry initiatives	Firms make a commitment to improve their performance beyond strict legal stipulations. This is commonly referred to as corporate social responsibility.	Voluntary initiatives could reduce first, second and third order impacts. However, the overall environmental and social impact depends on industry-wide buy-in.	ICT companies could commit to exceeding the requirements of the WEEE directive for recycling electronic waste in order to reduce the first order environmental impacts of ICT equipment. The ICT industry could put forward overall targets for "factor four" efficiency gains as part of an industry-wide strategy for reducing its environmental impact.
Monitoring and reporting	Firms commit to transparency and accountability in their activities. This allows benchmarking across industry, which can improve long-term performance.	Over time, benchmarking may promote sustainable development across first, second and third orders.	ICT companies could commit to triple bottom line reporting under the Global Reporting Initiative.The ICT industry could co-operate with NGOs and policymakers to develop sector-specific guidelines for triple bottom line reporting.
Government-supported initiatives	Information and financial support is offered by different public authorities to promote sustainable development.	Government-supported initiatives could improve knowledge on sustainability issues among business and create incentives for improved environmental and social performance at the first and second orders.	Government could finance and support social partnerships to tackle the digital divide. Local and regional governments could provide financial support for online local communities, particularly in rural and disadvantaged communities.