INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE UK

A SCENARIO FOR SUCCESS IN 2005

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EXECUTIVE SUMMARY

This report addresses the question**:**

What would 'success' look like in the field of ICT, in the UK, by 2005?

Success is defined here as maintaining and improving the commercial strength of UK-based organisations which develop, sell, or apply ICTs for national and global markets, and therefore enhancing our relative economic progress. It also means the UK improving its attractiveness for companies of all nationalities as a place to site value-adding activities which are based around ICTs. The purpose of having such a vision of success in ICTs in 2005 is to set a 'stretch target' for all the stakeholders in this area; and to give those involved in the UK science base a better idea of how a successful ICT activity would exert a strong 'pull' on the science base.

The report presents the result of a substantial research project, which culminated in a two day workshop in February 2000. At the workshop, which involved 20 individuals from ICT-based companies operating in the UK, from relevant Government agencies, and from the major public research bodies in the UK, a scenario for success in ICTs in 2005 was developed. The scenario is seen as *attractive*, being *more* than just a continuation of current trends, but still *credible*, given prompt action by those concerned. Some key elements of the scenario are:

- UK-based firms taking leading positions in the development of mobile computing, and contributing to new global standards in the area
- A further improvement in the availability of venture capital, and in experimentation with new business models
- Strong UK 'content' companies emerging in fields such as E-education and E-health
- Cheap access combined with demanding consumers for ICT services which creates a population which is also skilled and innovative in ICT innovation.
- Government agencies leading the way in releasing the commercial value of under-utilised information through the Internet.
- Rapid growth of B2B and B2C e-commerce.

The economic consequences of the scenario are dramatic:

- Production of ICT goods and services growing in its share of the economy and *adding 0.3% to the percentage GDP growth rate*
- Production of ICT goods and services being responsible for *one third of employment growth in the economy*
- A balance of trade deficit in ICTs being converted to a *trade surplus*
- *A reduction in price inflation of nearly one percentage point.*

These are profound and far-reaching changes. They would have major consequences for citizens, businesses and government. As scenario statements, they are based on painting a picture which is admittedly optimistic, but also *realistic*. What remains is for businesses and policy makers to take some of the steps which are implied by the scenario, in order to achieve the targets.

1. INTRODUCTION

The development and use of Information and Communication Technologies (ICTs) is one of the main drivers of the 'knowledge economy', which is now closely associated with the idea of the 'new economy'. We have already seen more than three decades of dramatic improvements in the power and cheapness of IT hardware and software. So much so that the 'IT revolution' has become almost a familiar feature of economic life. Nonetheless in the year 2000 we do seem to be crossing the threshold of yet another phase in this process. Indeed, some say we are moving into the 'second half of the chess board' with these technologies.[1]

The interactions between the Internet, mobile telecommunications, digital TV, 'bluetooth' technology, e-commerce, and new models of business organisation are creating opportunities and turbulence on a global scale. Giant global corporations appear threatened by new start-ups and are changing direction sharply. Small companies developing or using ICTs can grow from nothing to become giants in less than 5 years. National Governments face many challenges to their policy framework as a result of this evolving situation. How do fiscal, regulatory, industrial and social policies need to adapt to the 'new economy', if that is indeed what we now face? This report, and the project from which it arises, is set in the context of all of these policy challenges.

But our particular focus is on the importance of strong UK systems and institutions for the creation and diffusion of the scientific and technological knowledge which is at the heart of ICTs' contribution to the 'new economy'. One of the things we understand reasonably well about firms that are competitive in the development and use of ICT is that they are heavy users of the outputs of the publicly-funded *science base* in the countries in which they operate. These outputs include, first and foremost skilled graduates, but also extend to research collaborations and all manner of industry-university interactions which get grouped together under the rubric of 'technology transfer'. The UK is a small country which does 4% of the world's research, yet it produces 8% of the scientific output. It is (in part at least) because of the quality of this science base, and in particular because of its degree of 'connectedness' to the wider international science base, that the UK can be an attractive location for firms to develop ICTs and products and services based on ICTs. This is crucial in enabling the UK to participate in the wealth creation and quality-of-life benefits which ICT related industries create.

But, as the ICT revolution continues, the established patterns of interaction between industry and the science base, even in this most advanced of sectors, cannot stand still. New fields of scientific and technological research demand new modes of interaction; new skills demand new styles of training; new types of enterprise – often

[1] This relates to the story of a Chinese civil servant's request on being granted a prize for some service to the Emperor. He says: 'All I ask, Emperor, is that you grant me one grain of rice on the first square of the chess board, two on the second, four and the third and so on.' The Emperor, considering this a modest request grants it instantly. The point is that the chess board has 64 squares – so that, by agreeing to this 'modest' request, the Emperor had agreed to pay 18,446,744,073,709,600,000 grains of rice. Needless to say, the clever civil servant paid an even higher price – indeed the ultimate price. In the current context the relevance of the story is that by the 33rd square (the first in the second half of the 'chess board'), the amount of rice is, at over 4 billion grains, so large that it is effectively beyond perception.

service based – have to establish collaboration patterns with the science base which may differ from those of 'old manufacturing' firms with their traditional corporate R&D laboratories.

In order for public policy towards research spending, the organisation of public research, and the incentives for industry-university collaboration to evolve productively, we need a clearer vision of how the ICT part of the 'new economy' is taking shape. This report addresses this task by asking the following question:

- ***What would 'success' look like in the field of ICTs, in the UK, by 2005?***

What is meant by 'success ' in this context? The answer is:

> *Success is seen as maintaining and improving the commercial strength of UK-based organisations which develop, sell, or apply ICTs for national and global markets, and therefore enhance our relative economic progress. It also means the UK improving its attractiveness for companies of all nationalities as a place to site value-adding activities which are based around ICT. This does not mean that we ignore issues of ICTs in relation to the social and political fabric of the UK, but simply that we emphasise the narrower economic definition of success.*

Having a vision of the 'credible' level of success to which the UK could aspire in 2005 is useful because:

- Firstly, and most relevant to the Office of Science and Technology (OST) who commissioned the work, is the fact that such a vision will give us a sense of what sort of *'pull'* this level of industrial activity around ICTs would exert on the science base, in terms of requirements for skills and knowledge based collaboration. Consequently this will be a helpful input to the planning and organisation of the science base over the next few years.
- Secondly, a short range vision of the UK's future in ICT will have the benefit of providing a *common framework* for a wider range of players in industry, government, and the research institutions to shape their policies.

This report presents a 'scenario' for success in ICT in 2005, and the rationale for that scenario. A scenario is not a prediction or a forecast, so it is not simply an extrapolation of current trends (although it is informed by such considerations). A scenario is, in this case, a picture of a set of interlocking items in a jig saw. Some of the items are firms, their technologies, their markets, and their local and global connections. Other items are judgments about the policy and regulatory environment, the actions of other countries, the rate of development of markets and so on. The scenario presented here is one which is seen as both *credible* in the sense that the 'pieces fit together' and *attractive* in the sense that it represents an *achievable* step forward in the UK's share of the global wealth creation which is linked in some way to ICTs.

DEVELOPING THE SCENARIO

Before setting out the scenario it is important to briefly outline the process by which it was generated, and the people who took part.

During late 1999 and early 2000 a team of researchers at the ESRC-funded Centre for Research on Innovation and Competition (CRIC) in Manchester co-ordinated the project, the main activities of which were the following.

1. In November 1999 a small but representative group of about 20 individuals were identified from ICT-based companies operating in the UK, from relevant Government agencies, and from the major public research bodies in the UK. These people were 'recruited' to be the core members of a scenario-generating workshop to be held over 2 days in February 2000.
2. As preparation for the scenario generating workshop CRIC co-ordinated the preparation of the following 'inputs':
   - A substantial report on the current shape and size of the ICT producing and using industries in the UK, the trends in their growth and competitiveness, and their strengths and weaknesses. This was based on public data and on the interviews conducted with the people identified in point (1) above.
   - Background papers on how ICTs affect, and are affected by, such issues as: trends in lifestyles, globalisation of markets, policy toward social inclusion and exclusion, the environment, etc.
   - Three *initial scenarios* for the workshop which set the scene for debate, and which illustrated some *key relationships* in the economic and social structure of the UK which influence how the development and take-up of ICT products and services proceeds. These three scenarios defined to some extent the extremes of the plausible 'fourth' - most successful, yet credible - scenario for 2005.
   - An analysis by Cambridge Econometrics Ltd of how the various scenarios could be quantified in terms of their implications for GDP growth rates, employment, and inflation levels.
   - An analysis of the particular features of the linkages between companies and the science base which are important in the ICT field.
3. At the scenario workshop, the participants (who are listed in the box below and who had all received the above inputs beforehand) were presented with a short summary of the opening three scenarios. For the remainder of the workshop they went through a carefully designed process which broke the jig-saw down into its component parts, and forced them to make choices, for each element, about the most credible and desirable position for the UK in 2005. These choices were then re-assembled into the 'fourth scenario', which was then refined through discussion and quantified. This output was then further refined by CRIC into the version presented in this report.

The story told here then, is not a prediction, but it is a very believable image of what success could be like in 2005. It has been produced by taking the available public information; the collective wisdom of some experienced participants in the industry; and some relevant social science; and feeding these inputs into a short but intense process of synthesis. We believe it is a useful picture for orientating public and corporate policy discussions in this field.

THE WORKSHOP PARTICIPANTS

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Mr Ken Burgin	Managing Director, Motion Media Technology Ltd
Ms Lindsey Colbourne	Director, Projects in Partnership (facilitator)
Professor Rod Coombs	Director, CRIC, University of Manchester and UMIST
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Dr Hermann Hauser	Advanced Telecommunications Modules Ltd
Professor Andrew Hopper	Managing Director, AT&T Laboratories
Professor Pat Hughes	University Research Programme Manager, BT Corporate Programme
Mr Richard Lewney	Managing Director, Cambridge Econometrics
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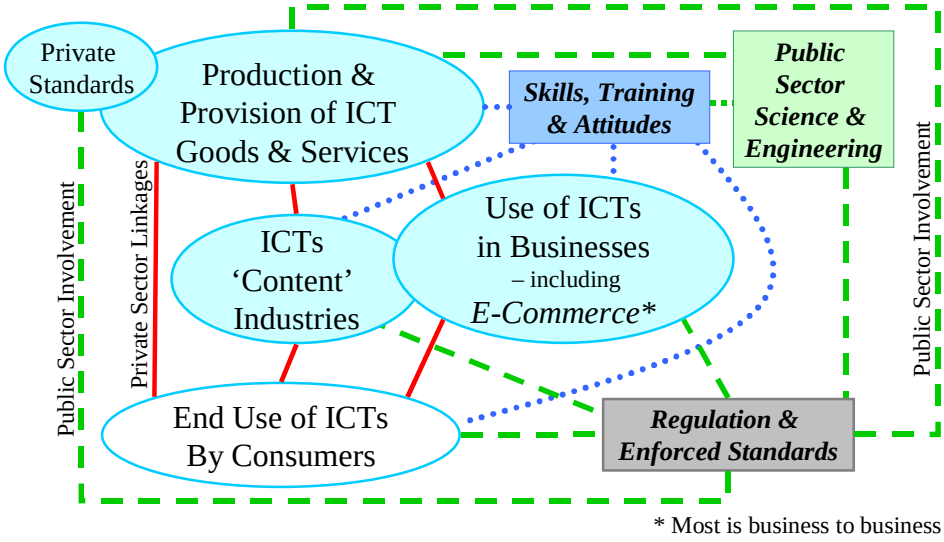
2. THE 2005 SCENARIO AND ITS RATIONALE

The ICT Sector in this Report



In this report, we consider only 'new' information communication technologies and associated activities based on electronic technologies, including 'content', which is created, stored and distributed using electronically based technologies.

At the start of the 21st Century, information communication technologies (ICTs) and related products are widely diffused within companies and households, as are ICT based 'content' services. Indeed, ICTs touch all our lives. Most of us have direct contact with ICT products and services on a daily basis – for instance, about 95% of households have a telephone, and 99% have a television. The economic impact of ICTs is also massive - by mid-February 2000, companies producing ICT based products and services, and ICT based 'content' producing firms, accounted for over a third of the total market capitalisation of the largest 100 firms listed on the London stock exchange (i.e., the FTSE-100 index companies). We note that this was before a number of 'dot.com' companies joined the index, the market value of which subsequently slumped.

In considering how ICTs will develop in the near future, therefore, we had to consider how a set of technologies which have already had a massive impact will impact further in the future. The current scale and significance of ICTs is easily underestimated; the future scale and significance even more so. Moreover, it is easy to dismiss the future development of ICTs as simply a process of 'roll-out', or the diffusion of already established technologies. Taking such a perspective would be a grave error. There is much to be won, and lost, in the next few years in terms of the development of information communication technologies.

Below, we consider a future scenario for the development of ICTs in the UK by 2005. We are concerned with both drivers and shapers. Although the scenario is mainly concerned with the economic and commercial impact of these technologies, some

consideration is also given to other aspects, such as the social and spatial impact of the technologies. The components of our scenario building are:

2.1 Technical Changes
2.2 Entrepreneurship, New Business Models and Venture Capital
2.3 'Content'
2.4 Innovative Business Use of ICTs, by Globally and Locally Networked Firms
2.5 Skilled Workers, and Innovative Consumers
2.6 The Importance of Science and Technology
2.7 Government:
- As Exemplar User
- Providing a framework for competition
- Encouraging entrepreneurship

For each of the topics listed above, there is a section in this report which captures the workshop participants' views of an attractive yet credible 'target' situation for the UK by 2005. Each section begins with a 'vision' of how things might look in 2005, which is necessarily rather melodramatic. This is followed by a statement of the rationale which is the real underpinning for our view of the trends and possibilities.

2.1 Technological Change by 2005

In 2005, computer chips are everywhere – and very cheap – performance to price has improved 10 fold since 2000, 100 fold since 1995. Bandwidth has exploded – aggregate bandwidth has expanded by 200 times since 2000. The world, or at least the advanced economies of the world, are highly networked – and the Internets are quick – despite the massive increase in their use. Most ICT devices are based on new standards, which are not controlled by any one company, so the technologies are generally cheap, and diffuse quickly.

It is often suggested that information communication technologies are in the diffusion phase of their evolution and, consequently, that 'the science has been done' and the technology will just roll-out. This perspective is wrong, for at least two reasons. Firstly, even though much of the technology now finding applications was 'invented' some years ago, finding innovative ways of applying technology is not a trivial matter – there is nothing inevitable about technological diffusion. Secondly, it is also wrong to assume that nothing remains to be done in the development of information communication technologies.

Moore's law still applies to the development of processing and storage technology developments. In accordance with this law, performance for price is still doubling every 18 months. New computer processing introduced in the next 18 months will match all previous processing, and new storage introduced in the next 18 months will match all previous storage. Both of these developments require tremendous technical efforts. However, within the five years from now to 2005, we can expect performance to price to improve 10 fold, and then 10 fold again between 2005 and 2010 – providing a 100 fold improvement between now and 2010. Outside the scope of Moore's law, but also significant, is the prediction that aggregate bandwidth can be

expected to double within 8 months. If this rate of development keeps up, aggregate bandwidth will increase by almost 200 times by 2005.

There are many developments which are on-going, or which are likely to occur in the next five years. For example, we have become accustomed to the personal computer (PC) and the WINTEL 'standard' of Microsoft (Windows) software and Intel microprocessors. But will that hegemony last another five years – even in office computing where WINTEL is most dominant? In other emerging areas of information communication technologies, such as mobile telecommunications and mobile computing, there are tremendous opportunities, for UK and European firms, to grow rapidly and set the standards, just as US firms have set the standards in most of the information technology domains that are now widely diffused.

The UK should therefore seek to be at the heart of these new developments. If we do not act we could become a moribund backwater in which technology is applied but not developed. To avoid this, the first thing that needs to change is the attitude that ICTs are fixed technologies, based on established - essentially foreign - standards, and undergoing a process of 'inevitable' roll out over which we have little or no control.

The dynamic nature of developments in ICTs also has implications for the science base and for government, to which we return later.

2.2 Entrepreneurship, New Business Models and Venture Capital

It is 2005 and the massive expansion in the use of Internets is due to both the improved technology (no more waiting for ages to gain access to 'pages') and to amazing new applications. To give you just one example – boring old shopping. Except it isn't boring any more – not the shopping we choose to do anyway. Routine shopping is now computerised. Because microchips are so cheap, virtually all products have a microchip attached to them or their packaging – and these 'talk' to a central household computer. So the cheese talks to the fridge, telling me it needs to be used up – and as things get used up they automatically record the need for replacements on an electronic shopping list. The bin is also excellent for this – as old packaging gets binned, the central computer records the disposal and adds the item to the shopping list. I can intervene of course, ask something not to be ordered, or add something new, but the ordering is done by the computer, which phones the five major supermarket chains and negotiates my order. It seeks out the lowest price items. Actually, all standard items now have an identical price, as prices are so transparent - to computers that don't get bored shopping around – that margins are wafer thin. The price of some specialist goods does vary, but for more expensive items, I can set the time frame over which the item is sought, and bought – and the computer contacts GOGETIT.COM which is an on-line auction system which groups together buyers to get items at the lowest possible price. All my deliveries are made by the shops using advanced distribution systems, and at a time I want, so I have more time to slob out with the 3-D interactive surround vision tele and 'watch' Liverpool destroy Manchester United 5-0 in the final of the World Club Championship. Good things come to those who wait!

With a few exceptions, most notably Vodafone, the UK is not currently home to the world's largest ICT based firms, most of which are based in the US, with others in continental Europe and Japan.[2] There is, however, no reason why the UK should not become home to several highly successful new ICT based firms. Very rapid corporate growth is possible in information communication technologies, as the likes of Microsoft, Intel and Cisco Systems have shown. The UK has generally not shared in this experience, although the rapid (if sometime turbulent) growth of ARM, Baltimore Technologies and Psion shows this sort of success is possible in the UK. To facilitate these successes, the UK must provide the framing the conditions under which a larger number of entrepreneurial, and potentially highly successful, ICT based businesses can become established and grow.

In the 'goldrush' of the 'new-economy', it is vital that the UK is at the forefront of applying new ICT technologies. Within this, new business models are as important as the technologies being applied. Direct Line illustrated how the application of ICT technologies can transform established industries, in that case insurance.

New internet sites are also permitting rapid price comparisons for goods such as cars, which are driving down prices. More innovative service providers are also emerging. Letsbuyit.com is a good example – whereby individuals essentially pool their buying power to lower prices. Often, it is the very simple ideas that prove highly popular and successful. The short messaging services provided by mobile telephone companies are another good example. It is likely that these will be used for local advertising in the near future.

This sort of innovation and entrepreneurship through new business models must be encouraged and flourish if the UK is to lead in the new-economy. Equally, however, care must be taken that these ventures are secure and trustworthy – consumers' trust of these new business models is vital to their success and development. Some forms of regulation will be needed to encourage the necessary sense of security.

Venture capital is growing rapidly in the UK, although there is still a lack of ambition on the scale of that seen in the US. Success breeds success, not least in venture capital. As more successes arise, more specialist venture capital funds will be established with fuller knowledge of the technologies involved and of the services required by the entrepreneurial ventures. An aim should also be the formation of a European equivalent to the NASDAQ stock exchange, which has been so effective in backing technology based ventures in the United States.

The government should encourage these developments – not least through favourable taxation of entrepreneurial ventures. Schemes such as the SMART Award scheme are also very useful, although this needs to be expanded considerably.

[2] Although many of these firms have activities in the UK.

2.3 'Content'

In 2005 content is king … I said I 'watched' Liverpool destroy Man United, but watch is too passive a term. Through the use of head-cams the viewer gets to the heart of the action – I can get Robbie Fowler's view, Michael Owen's or Sander Vesterveld's. Lets face it, watching footy on the tele was often a bit dull – up to 80 minutes of tedious attrition for 10 minutes of fantastic action – this way we get to live through the best 10 minutes multiple times, from a player's eye view. Of course, you can watch footy the conventional way, if you want. And beyond footy, the development of digital TV means that television viewing schedules can be highly personalised. But the great thing about all this is that it is so cheap. By not allowing the same companies to control content and carriage, the Government has ensured that competition is intense and the subscription price is low. Indeed, lower than the old BBC licence.

The creation of 'content' is one of the UK's traditional strengths. The UK has a thriving television and radio broadcasting industry, as well as strengths in music production and publishing, plus new strengths in the development of computer games. 'Content' embraces all of these activities. As the ICT revolution unfolds, 'content' will become more not less important. The English language also offers the UK a tremendous potential advantage for the development of content provision over the Internet (or Internets). The development of new forms of content will further stimulate the development of the infrastructure, fuelling investments in bandwidth, for example, but also stimulating the development of innovative services providers.

New forms of 'content' will emerge, with tremendous opportunities for public sector services as well as private sector services. The delivery of health and education services 'on-line' are ready examples. There is no reason why the delivery of health services through the use of interactive information communication technologies should not take-off and powerfully augment traditional mechanisms of health delivery. For example, by 2005, half or more of health centres could undertake patient specific transactions on-line, with face-to-face interactions between patients and the health provider being thoroughly prepared by prior electronic exchange of the relevant information beforehand. Beyond this, expert systems could facilitate self-diagnosis of minor ailments.

Education services should also adopt these new forms of delivery, with the emphasis on bringing education to people, rather than necessarily bringing people to educational establishments. This will open opportunities for export earnings from an e-university, for example.

Within the UK, the aim should be to provide open access to education and health services on-line. Open access, at a low cost, should also be the aim in the provision of content to the public where previously that content was 'free-to-air'. This is a significant issue for competition policy.

2.4 Innovative Business Use of ICTs by Globally and Locally Networked Firms

2005, and the ten fold improvement in the performance to price ratio of computers in the last 5 years, the two hundred-fold expansion in bandwidth, and the Government's policy of encouraging investment in ICTs through incentives has meant that the UK has amongst the highest levels of ICT diffusion in the world. The high use of networked ICTs by consumers to seek out products and services (both by themselves and by computers on their behalf) means that price competition is intense, and profit margins are thin. Generally, companies have to innovate to survive – they have to find new ways of doing things that appeal to consumers who will be prepared to pay more for them. The same applies to business-to-business interactions. The great thing is that because the UK is at the forefront of these developments, many of the new services are invented here, as are the protocols upon which they are based. Many of the services are made available to foreign companies and consumers, whilst many of the service formats are licensed, earning valuable foreign earnings for the UK.

There is tremendous potential for the delivery of services through ICTs. For example, the vast majority of financial transactions could be made 'on-line'. Furthermore, a large proportion of routine shopping (perhaps even the vast majority) could be ordered 'on-line'. There is no reason why these changes could not come about very quickly – within five years. Advanced distribution systems could be used in association with on-line ordering to distribute goods, thereby reducing, rather than increasing, traffic congestion and thus improving quality of life. Potentially, these technologies could also reduce inequalities of access to goods and services within the UK population.

ICTs and electronic commerce also offer the potential to both expand markets and provide efficiency savings. The transparency offered by rapid price comparisons over the Internet will also reduce margins, providing a further stimulus to innovations geared to efficiency savings. The engagement of small firms in these activities is central if competition is to be maintained.

The rapid (if turbulent) development of Internet based trade in the UK will also spur the development of new business support services. All of these developments rely, however, on the Internet becoming a trusted framework over which commercial activities can occur. Government regulatory activity can assist with developing this trust.

Success for the UK in ICTs also requires firms to be both locally and globally networked. ICTs are characterised by the development of de facto standards - the classic example being the Windows operating system. It is vital that UK firms play a role in the formation of future standards, such as the Wireless Application Protocols (WAP) now being developed (and the future derivatives of these), rather than these being developed and dominated by foreign companies. In this area, success breeds success, which makes a 'seat at the table' doubly important. Being in possession of the best technology is certainly one dimension of this process, and this means the UK must catch up, if not overtake, its major competitor countries in terms of the investment made by UK ICT companies in research and development. Links with universities are also very important here.

Firms should also network locally – as demanding customers of each others' products and services, and innovative clusters of ICT companies could certainly emerge in the UK. Large firms could also assist this process through the expansion of their corporate venturing activities.

2.5 Skilled Workers and Innovative Consumers

2005, and the Government's decision to give everyone in the UK a free computer using the proceeds from the spectrum allocation auction has proven to be inspired. The computers use the same operating system as the latest mobile phone communicators – an operating system developed by a British based company, but also adopted by several of the world's leading producers of mobile computing and communications devices. These computers also allow consumers to tap into an electronic national grid (for learning, health diagnosis, etc.). This encourages the development of unrivalled computer familiarity and literacy skills in the UK, and encourages the creation of firms to provide services through 'the grid' to other firms and consumers. As mentioned earlier, these firms then sell the same or similar services to consumers in other countries.

A skilled and ICT literate workforce is vital to the UK's future success in ICTs. This is for the obvious reason that without the skills we cannot create the products and services that will compete on a world stage – instead we will become increasingly dependent on products and services developed elsewhere. But an educated and ICT literate workforce is also vital to the UK's future success in ICTs because such a workforce would provide a more demanding customer base, in terms of the quality of products and services accepted. A demanding consumer base is vital to innovation in ICTs.

To achieve a skilled and ICT literate workforce both Government and industry must be prepared to invest. Government in education; industry in training. Education should not be confined to the young – people of all ages should have access to education – the development of an e-university should be hastened to encourage access for all.

Innovative and demanding consumers also play a central role in the diffusion of new technologies and new business models. New ICTs, and products and services based on - or delivered through – ICTs, offer potentially enormous advantages to consumers in several ways. These include improved transparency – making it easier to compare products and prices between providers, freeing up time – no longer will consumers have to actually visit banks or shops if they do not wish to. There is tremendous scope for ICTs to enhance the quality of life in Britain.

There is, however, a recognition that much of this depends on trust, and the development of systems that provide security and provide privacy where necessary.

2.6 Importance of the Science Base

In 2005 the UK science base, particularly in applied sciences, is rapidly becoming the envy of the world. A few years ago it was recognised that, if the UK's universities were to attract the best talent, something had to be done about academic pay – particularly in those areas where the private sector pays handsomely – such as in computer sciences, but also in economics and management. The pay structure was reformed radically, no longer are professors of computer science paid the same as professors of archaeology or anthropology. Further reforms have also encouraged the universities to increase their collaboration with business and society generally. A large section of the public funding of universities supports collaborations with industry. Universities still seek to do first class academic research, but publishing papers is no longer the be-all-and-end-all of performance.

We have emphasised above that scientific and technological developments in ICTs are on-going – existing technologies are not merely been 'applied'. If the UK is to be in a leading position in the development and application of ICTs it needs to retain and strengthen its scientific and technological base in these and associated areas, within research oriented Universities.

To achieve this both reform and investment are required. The issue of low academic pay cannot be avoided. Even the very best UK universities are experiencing increasing difficulties in attracting talent, particularly in disciplines in which there are private sector opportunities. The most significant reason for this is the large and growing difference in pay between academia and the private sector. However, UK universities are also losing out to universities in other countries, notably the US, in the competition for the best talent. If we want a strong science base in this country we must reward scientists appropriately.

Pay, however, is not the only issue. The funding mechanisms should be reformed to encourage a broader portfolio of research including both 'basic scientific' research and 'basic technological' research. Under the current framework, the research assessment exercise encourages the publication of academic papers in academic journals. This research is useful to industry in the long run, and produces good post-graduates, but does not encourage university-industry collaboration. The funding bodies should consider and give incentives for a broader set of contributions made by academia. Foremost amongst these is contributions to industry. This would encourage individual academics to take an interest in industry, and the problems faced by industry – so encouraging a more effective form of partnership between academia and industry. This 'third leg' of funding, that for success in interactions with industry, should be expanded, alongside continued support for success in teaching and for success in research.

Reform is also required to the process of assessing research proposals. The peer review process has many advantages, but amongst its disadvantages is a tendency to support conservative science. The process should be adapted so that more radical proposals also gain funding – possibly through the backing of an elite group of 'star scientists'.

Reform is also required to the treatment of intellectual property by universities. At present, universities are too defensive about their intellectual property, to the extent that much remains unexploited. The universities should be willing to trade intellectual property for equity in start-up ventures, with the understanding that if the venture fails the intellectual property rights revert to the university. Alongside this, reforms to the funding mechanisms outlined above will encourage academics to work directly with industry.

Beyond these changes, there is a need for more interdisciplinary teaching and research – the UK needs many more graduates with science based technological knowledge. The decline in popularity of science and engineering based disciplines in (favour of social sciences and the humanities) amongst students must be reversed if we are to have sufficient technical skills to compete in the 21st century.

There is also an urgent need for entrepreneurship courses, to heighten the awareness amongst students, and develop the skills required, for entrepreneurial ventures. In this new century there is likely to be a growing tendency towards an economy based on small firms and self-employment – young people will need the skills to succeed as entrepreneurs or as self-employed individuals.

There is also a need for re-education opportunities. We should move away from the outdated notion that education is for the young and precedes working life. People should be encouraged to come back to education to learn new skills throughout their working lives. Within this there are significant opportunities for electronically delivered, and interactive, education. E-science also presents a tremendous opportunity.

To achieve 'success', the UK should aim for a situation in which rival countries complain: 'the UK has an unfair advantage in science and technology'. In this situation, the UK science base would serve as a major attractor of talent, as a source of new business ideas, a problem solving resource, and would be the provider of highly educated and multi-talented workers. To achieve this, the UK science base requires both reform and investment.

2.7 Government Action

Success will depend on the right economic, business and cultural framework, which can be shaped by Government policy. To some extent this is through providing the right economic framework (for example, the tax treatment of entrepreneurial success), but the Government is also a major purchaser of ICTs, and the public sector has tremendous potential as a provider of ICT based services. We address three roles of Government in helping the UK achieve 'success' as a leading country in the development and application of ICTs.

2.7.1 Government as an Innovative, Exemplar Provider and User of ICTs

The public sector in general, and Central Government in particular, are major purchasers of ICTs. They also have enormous potential as suppliers of ICT based services. The public sector in general, and Central Government in particular, should become an exemplar user / provider of ICTs

Government also has a tremendous amount of information which could be made available to the public and to companies operating in the UK. The value of much of this information can be enhanced by being made available to companies. The Ordnance Survey is an excellent example of this already taking place. Ordnance Survey map information is used by many commercial organisations, for the benefit of both the agency and the organisations which use the information. Other agencies, such as the Drivers and Vehicle Licensing Agency (DVLA) should be encouraged to follow suit. Obviously, details of individuals must remain private.

Health care and education are both areas of tremendous potential for ICT based services. Health services, such as consultations, could be provided on-line through expert systems – facilitating self diagnosis and symptom reporting. Where patients do need to actually visit a doctor, electronic data exchanges could improve the efficiency of those visits. Similarly, education should become much more ICT based – with the potential for on-line own speed learning, and for bringing education to the people, rather than bringing people to educational establishments. Fully developed on-line health and education facilities would also provide export opportunities, and opportunities for new forms of overseas aid.

The public sector in general, and Central Government in particular, are major buyers of ICT equipment and services. The Government could use this position to stimulate demand for innovative equipment and services (developed in the UK), rather than seeking lowest cost solutions (particularly from large, long established and/or foreign firms). The Government should also consider adopting the policy of the United States, where Government is obliged to procure a significant proportion of its total procurement from small firms.

2.7.2 Government Providing the Framework for Competition

The Government will play a central role in providing the framing conditions for competition (both nationally and internationally), which is vital to the development of a healthy ICT sector in the UK.

Competition is vital. This means British Telecom's monopoly on the local loop must be ended. It is clear that cheap access through unmetered calls is fundamental to the rapid take up of the Internet, and Internet based services, in the UK. New technologies will provide alternative modes of access (and the cable network in particular has tremendous potential), but fixed line telephony is the most diffused technology, so competition within this technology is vital.

Transparency is also vital, and the Government has an important role in ensuring fair competition through transparent pricing. The pricing of new ICT products and services is often clouded in mystery, much of which is intended to make direct price comparisons between rival products or services difficult or impossible. This practice tends to increase the service providers margins but reduces take up and use. In relation to this, the Government should also encourage the formation of trusted information intermediaries. These would provide consumers with clear answers to questions such as: 'what are the five best mortgage deals available to me?'

The principles of competition policy should be that there is room for new entrants, and transparent pricing. Where licences are granted, such as for the radio spectrum, or television broadcast rights, the bidding process should be open and competitive. The aim should be to encourage the rapid roll out of the new technology, whilst also providing access at a fair price. The convergence of carriage and content provides an important if difficult issue. New media groups increasingly own both the content (or rights to the content) and the mode of carriage or delivery (i.e., the access technology). This provides significant potential for anti-competitive behaviour. The Government should seek to separate ownership of content from ownership of carriage in order to promote fair competition.

Standards formation is another important, if difficult issue. Because *de facto* standards emerge, this can reduce competition if they are privately owned and not made accessible to new entrants.

Another issue is providing a framework for electronic commerce – this includes regulations, tax, and the legal basis. Trust and accreditation issues also arise. Without these, e-commerce will not take-off significantly in the UK.

It is difficult to identify the additionality of a successful policy framework. However, the wrong policy framework will quickly lead to failure. The success of the policy framework can be detected indirectly through low prices (as an indicator of competitive environment); widespread accessibility (to users); the quality of the network; the extent of openness to new entrants; and the extent of innovation (and experimentation).

2.7.3 Government Encouraging Entrepreneurship

The third role for Government is to encourage entrepreneurship through favourable taxation and other measures. This includes taxing capital gains on the same basis as they are taxed in the United States, which is the principal competitor country in these technologies. Options should also be taxed favourably to encourage participation in

entrepreneurial ventures. Taxation apart, another area requiring reform to encourage entrepreneurship is the planning laws. These should be reformed to make the planning process simpler and quicker – and aimed at assisting business development rather than stifling growth. The business rates should be de-nationalised – that is, business rates should be set locally so that local communities have the opportunity to encourage investment in their own area.

* * * *

Some of the key features in the overall scenario described above are summarised on the next page as a set of embryonic 'performance indicators' for ICT in the UK

INDICATORS OF SUCCESS FOR THE UK IN ICTs BY 2005

Widespread access

- Amongst the public and amongst SMEs
- This means a high level of use of the products and services offered by ICT –producing firms by an aware public.
- Companies, communities and individuals would be able to access and use effectively top-quality ICT in the support of the production, distribution and application of knowledge.
- Rapid growth of web / e-commerce / e-business service to SMEs.
- Higher standard of use in the under-performing 'tail' of small firms.
- All citizens should have full access to e-commerce, email, the Internet, etc.
- The 'new economy' constitutes a significantly larger share of UK GDP than in the OECD average.
- High bandwidth availability, coupled with low access and use charges.

Key players in global networks

- Some ICT-based companies that are global leaders.
- UK is a strategic partner of choice in significant global networks developing leading edge ICT.
- Innovative use in fast-changing areas (e-commerce).
- Some successful new and emerging firms in high value-added activities.
- UK-based ICT companies will have 'more than their fair share' of participation in global networks/alliances of IT providers.
- Significant links between UK and European industry and the UK science base.

High rates of co-formation

- An internationally high level of start-up activity in ICT based businesses in the UK.
- 20 or more fast growth ventures, equivalent to ARM or Baltimore Technology of today.
- Many of these fast growing, high potential firms, will emerge from the UK science base (directly and indirectly).

Higher industrial research and development

- A higher level of industrial R&D by domestic firms
- A higher level of inward research investment from foreign owned firms.

ICT contributing to quality of life

- Lower prices generally through increased transparency
- Lower road traffic congestion due to ICT-led gains in efficiency and changes in life style.
- Banking can be done entirely from home / office. At least half of all routine shopping can be done without an access charge over the Internet.
- Interesting new content, including health and education services from the public sector.
- High quality employment in ICT based activities – not just a headcount of the number of ICT jobs as this fails to consider the quality of the work involved.
- Opportunities, particularly using ICTs to enhance the efficiency and/or effectiveness of new and existing services.

Other Considerations

- ICTs contribution to GDP up by 50%.
- Big improvement in technological balance of payments.
- Demonstrable value to GDP with the UK uptake greater than EU average.

3. THE ECONOMIC DIMENSIONS OF THE SCENARIO

(The analysis in this section was provided by Richard Lewney of Cambridge Econometrics Ltd)

In this 'target' scenario for ICTs in the UK in 2005, we have defined success in economic and commercial terms. So how successful is 'success' in these terms? What does it mean in terms of economic growth, jobs, the balance of trade, prices and so on? In this, the final section of the report, we give some answers to these questions. The answers are based on taking recent trends, but not simply extrapolating them blindly. Instead, we have designed the extrapolation to take into account the qualitative features of the 'success' scenario. This shows us what there is 'to play for' in the UK between now and 2005.

3.1 The Distinction between Production and Diffusion

Public debate over whether or not the UK is 'succeeding' with regard to ICTs incorporates questions such as:

- is the UK an attractive environment for the dynamic growth of firms that are springing up to supply the rapidly-growing markets for new ICT products?
- is the UK an attractive environment for foreign direct investment by multinational firms that dominate some areas of the technology?
- how does the record of UK firms compare with that of other developed countries in the securing of international patents in the technology?
- are UK firms adapting rapidly to take advantage of the opportunities made possible by the advent of e-commerce?
- how do the penetration rates of Internet access in UK households and schools compare with those of other developed countries?

The first three of these are examples of questions that relate to success with regard to the *production* of goods and services that embody the new ICTs. In principle, the economic benefits that would follow from success in these areas could accrue regardless of the size of the UK market for them. Indeed, the UK market is typically only a modest contributor to the world market. The second two are examples of questions that relate to success with regard to the *diffusion* of the products and services that embody the ICTs. In principle, the economic benefits that would follow from success in these areas could accrue regardless of whether or not the products are produced in the UK, or entirely imported. The Government is currently more concerned about the take-up of e-commerce across the economy than the extent to which, say, the web design software tools are written in the UK.

In analysing the economic impact of the technology, it is therefore important to be clear as to whether any particular effect is primarily concerned with production or diffusion. If UK success is to be measured by capturing a reasonable share of the world market for a fast-growing, technologically-advanced product, we are concerned with *production*. If UK success is to be measured by securing the benefits of lower prices, increased productivity or taking advantage of the opportunities offered by a new product to underpin improved competitiveness in other activities, we are

concerned with *diffusion*. In our scenario, both production and diffusion are important, and this is reflected in our economic analysis.

3.2 How the Contribution of ICT Production to the Economy is Measured

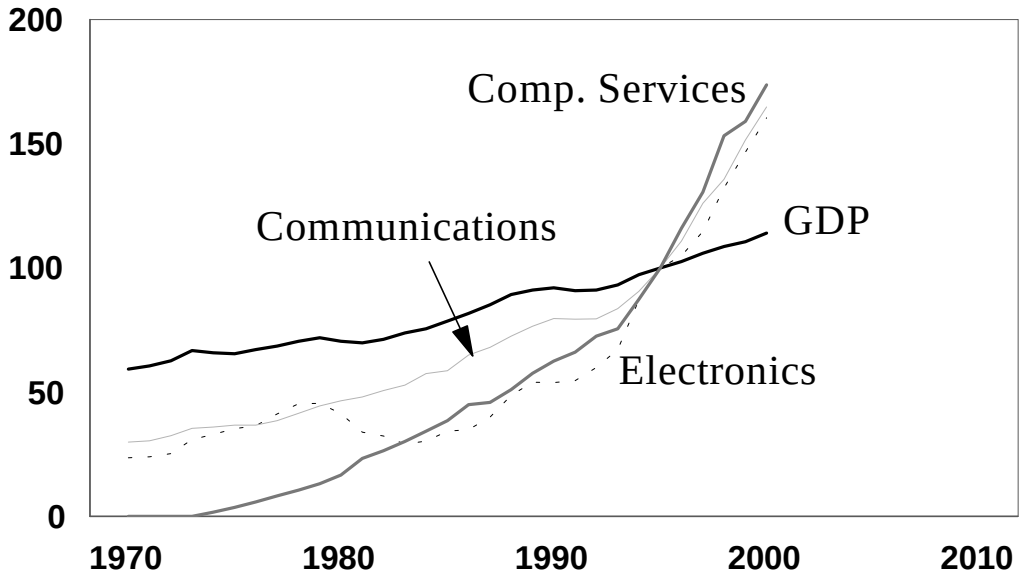
The conventional measures for the direct contribution of production of any industry or group of industries to the economy are:

- value added
- employment
- exports, the trade balance and other balance of payments flows

Value added measures the incomes generated in the UK from production activities. These mainly comprise profits and wages and may accrue to UK residents or to residents abroad (i.e., profits may be repatriated in the case of plant owned by an inward investor). *Employment* measures the jobs supported in the UK by the production activities, the wages for which are paid out of value added. Together, value added divided by employment is a common measure of productivity, and high-

VALUE ADDED IN ICT SECTORS AND THE WHOLE ECONOMY

(1995=100)



productivity jobs are often also high-wage, high-skill jobs.

Another way in which production contributes to economic well-being is by earning foreign exchange which allows the UK to purchase imports. This contribution can be measured by *exports* of goods and services, but, since globalisation is having the effect that both exports and imports are rising in many industries, it is sensible also to examine the *trade balance*, that is the difference between exports and imports. Finally, R&D-intensive firms can contribute to() the balance of payments through foreign royalty earnings from licensed technologies.[3]

[3] Where revenues are earned from royalty or licence payments for the use of technology that the firm has developed for use by others. These appear in the national accounts as earnings from

Other, indirect ways in which ICT production might be regarded as contributing to the UK economy are through the demand which they create for inputs produced by other industries ('backward-linkage effects') and the demand generated when ICT workers spend their wages. Such effects are typically examined for the case of a local economy in which a major plant opens or closes. However, for a reasonably large, open economy such as that of the UK, it is in our view inappropriate to record such effects as attributable to the ICT industry, particularly because of the risk of double counting.

3.3 Estimates of the Contribution made to the Economy by ICT Production

3.3.1 Value Added

The chart shows trends in value added (measured at constant 1995 prices) in the principal ICT sectors over the past two decades, indexed to 1995=100, together with the trend in overall UK GDP. Two features stand out. The first is that all the sectors have a much higher long-term growth rate than does the economy as a whole. The second is that this growth rate accelerated in the 1990s, to about 10% per annum.

Together, these three industries account for nearly 8% of UK GDP,[4] up from about 4% in 1990. Their direct (accounting) contribution to overall annual GDP growth is therefore currently typically around 0.7 percentage points, or approximately one-third of typical estimates of the UK's long-term growth rate.

The 2005 scenario set out above does not set precise projections for the scale of growth that might be expected if UK producers are 'successful'. *However, it is clear that the scenario implies growth at least at the rate seen in recent history, and perhaps* somewhat higher. This suggests that the ICT industries would be contributing about 1 full percentage point to the annual rate of GDP growth in 2005. This constitutes a significant increase in the already substantial contribution ICT related activities make to economic growth.

3.3.2 Employment

The trends with regard to employment are quite different across the ICT sectors. In electronics employment has fallen over the long term, although it has stabilised recently. In communications employment has been broadly stable. In computing services employment has grown very rapidly. Together these three sectors account for a little over 4% of the whole economy's employment (measured as a simple headcount), less than their share of GDP because the ICT sectors have a higher than average level of productivity.

Because of the strong growth in computing services, the three ICT sectors have together increased their employment rapidly since 1995, at a rate of about 7% pa compared with about 0.6% pa for the economy as a whole. Hence, their direct

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'royalties, licence fees, etc' and are treated as the export of services. However, the industry that originated the patented products is not distinguished in the official data.

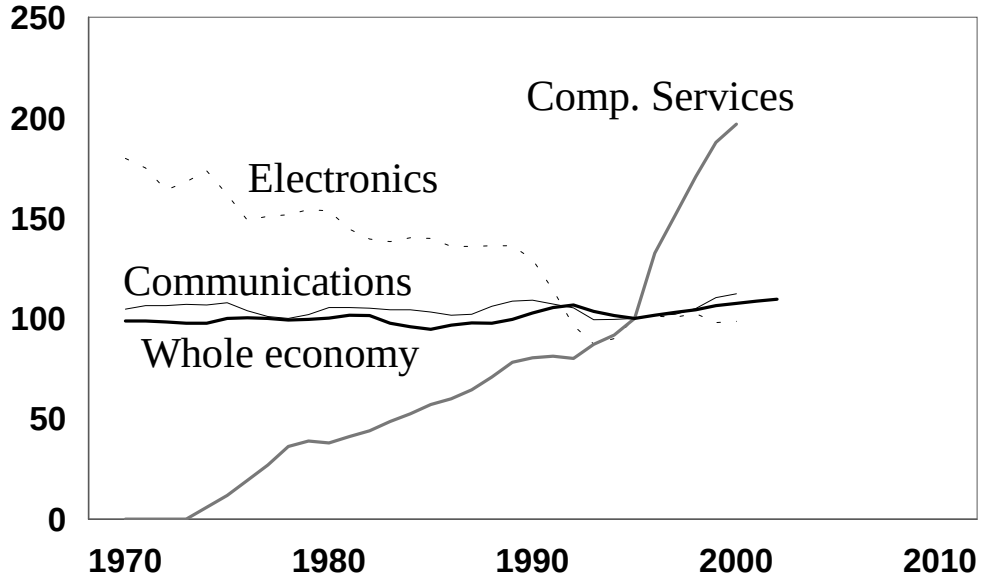
[4] In a strict and narrow sense, using gross value added at basic prices, which is the appropriate concept when comparing an industry's value added with the total for the economy as a whole.

(accounting) contribution to annual employment growth has been about 0.25 percentage points, or a little under half of the UK's total employment growth.

The period since 1995 may not have been representative of the longer-term trend for employment growth, either in the ICT industries or in the economy as a whole. Our best estimate is that in the longer term whole-economy employment growth will be slightly higher (say 0.7% per annum) and that ICT employment growth may be slightly lower. However, the broad conclusion for the contribution of ICTs to overall employment growth remains*: ICT sectors together are expected to account for over a third of overall employment growth in the period to 2005.*

EMPLOYMENT IN ICT SECTORS AND THE WHOLE ECONOMY

(1995=100)



3.3.3 Trade and the Balance of Payments

Data for trade in services by sector are not as reliable as those for trade in goods, but it is clear that among the three ICT industries trade is dominated by the electronics sector. Of total estimated exports for the three sectors of about £30bn in 1998, electronics accounted for £26.7bn. Similarly, ICT imports are dominated by electronics, which accounted for some £29.4bn out of a total for the three sectors of £32.6bn.

These data show that there is currently a trade deficit of about £2.6bn for the three sectors. However, not much significance should be attached to this fact as there is no presumption that it is desirable for the UK to run a trade surplus for any particular industry or group of industries. What would be of greater interest would be to determine whether there is a trade surplus or deficit in the higher value-added, less commoditised goods and services in which a developed country should be specialising, but unfortunately the data do not readily support such analysis.

Movements in the trade balance are quite erratic, but the broad trend was a gradual deterioration in the 1980s, followed by stabilisation in the 1990s. In the 2005

scenario we expect both exports and imports of ICT goods and services to grow more rapidly than UK production, reflecting the effects of specialisation and globalisation. *However, in the 'target' scenario described above, it is reasonable to see the trade deficit of £2.6 billion in ICT being transformed into a surplus of around £2 billion.*

3.4 How the Contribution of ICT Diffusion to the Economy is Measured

The contribution of ICT *diffusion* to improved economic well-being and performance is much more difficult to measure but takes essentially two forms:

- a boost to the performance of UK industries (including the public sector) for which ICT products and services form key inputs
- lower prices and higher-quality goods and services for UK households

Improvements to industry performance are likely to take a variety of forms but should be evident in indicators of productivity (value added per hour worked), profitability, and trade performance.

The benefits to UK households are most apparent in the form of lower prices. To the extent that the superior quality of more technologically-advanced products and services is captured in the statistics, this also tends to take be represented as lower prices for the same functionality (or the same amount of spending buys greater functionality).

3.5 Estimates of the Contribution Made to the Economy by ICT Diffusion

3.5.1 Improvements to Industry Performance

While some industries are more ICT-intensive than others (banking, for example, compared with clothing manufacture), the application of ICTs is, of course, pervasive throughout the economy. This means that the effects are likely to be highly diffused and therefore substantial, but also difficult to attribute to ICTs. There are, of course, many factors that influence industry performance and there is a risk that all the recent improvements in performance are attributed to ICTs alone.

Of the indicators noted above, the one most proximate to the production process is the level of productivity: improvements here will lead to improvements in profitability and trade performance, for example. It is well known that empirical studies at the level of the whole economy have typically been unable to identify any improvement in underlying productivity growth that could be attributed to ICTs. The most popular explanation for this puzzle is that the bulk of the improvements brought about by the implementation of ICTs have in the past been in the form of quality improvements which have not been properly captured by the data, particularly in the service industries. It may be that process changes that ICT-based products and services are now facilitating are different in kind, and will be better reflected in the economic statistics. For example, the shift from high-street branch banking to telephone and Internet banking is resulting in very marked net reductions in employment in return for substantial investments in ICT.

In the past five years productivity growth has increased sharply in the US: over 1997-99 the rate of productivity growth was about 1 percentage point higher than the long-term average over 1975-95. Some commentators have drawn the conclusion that this reflects the impact of ICTs, although evidence for this is rather scant. Also, it would not be surprising if firms responded to a tight labour market by finding ways to raise output per worker, so some of the effect may be cyclical. There is no evidence yet of any similar increase in productivity growth in the UK. But the target scenario would see this productivity growth starting to appear as we approach 2005. *Our best estimate for the impact of ICT on economy-wide productivity growth in the 2005 scenario is therefore more cautious than some of the 'New Economy' advocates, say an increase of 0.2 percentage points.*

3.5.2 Lower Prices and Higher-Quality Goods and Services for UK Households

Rapid technical change is resulting in large price reductions in ICT goods and services. These help to depress the overall rate of consumer price inflation both directly - as households benefit from lower prices of ICT products that they purchase - and indirectly - as lower production costs are passed through the supply chain across the range of products.

On a conservative estimate, price falls in a small number of ICT consumer products reduced overall RPIX price inflation directly by 0.2 percentage points over the 1996-99 period. As ICT goods and services take on a greater weight in overall household spending it is plausible that this direct impact on inflation will increase.

In addition, the growth of e-commerce will lower search costs and hence effective prices in both the business-to-business (B2B) and business-to-consumer (B2C) markets. The impact of these price reductions varies greatly from product to product, and the scale of impact depends on the speed with which the share of the market taken by e-commerce grows. Preliminary calculations suggest that B2C could reduce overall consumer prices by 5% by 2005, resulting in a reduction in measured inflation of perhaps 0.3%. The impact of B2B could be even larger, at around 0.5%. Some of these effects are likely to be of the nature of one-off adjustments, similar in character to the impact of the introduction of high-productivity large-scale out-of-town hyperstores on retail margins and prices, and so the effect on inflation may begin to wear off as the market share taken by e-commerce reaches a plateau. But this plateau is unlikely to be reached for several years. *Taken together then, these price reductions could reduce inflation by nearly a full percentage point by 2005.* In the context of already low inflation, this is quite a dramatic effect, with further positive knock-on effects for economic growth.

4. Conclusion

So the economic measures of success in the target scenario are very significant indeed:

- Production of ICT-based goods and services growing in its share of the economy and adding 0.3% to the percentage GDP growth rate.
- Production of ICT-based goods and services being responsible for one third of employment growth in the economy.
- A balance of trade deficit in ICTs being converted into a trade surplus.
- A reduction in price inflation of nearly one percentage point.

These are profound and far-reaching changes. They would have major consequences for citizens, businesses and government. As scenario statements, they are based on painting a picture which is admittedly optimistic, but is also *realistic*. The workshop participants feel that these are credible views of what can be achieved. What remains is for businesses and policy makers to take some of the steps that are necessary (and have been described in this report) to achieve these targets.