Trends in connectivity technologies and their socio-economic impacts

Final report of the study: Policy Options for the Ubiquitous Internet Society

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TR-776-EC

July 2009

Prepared for DG Information Society and Media

Preface

This report is intended to inform the European Commission's DG Information Society and Media in developing its policies for the period 2010-2020. It is targeted to policymakers with expert knowledge of the field.

The report summarises the work conducted in the study: 'Policy Options for the Ubiquitous Internet Society'. It builds on three prior documents: 1) a briefing paper on Connectivity Challenges; 2) The Interim report containing trend analysis, scenario development, modelling of socio-economic impacts and a review of changing business models; and 3) a Workshop Report. In addition an analysis was made of policies in the US, Japan and South Korea to provide a reference for the EU's own policy in the field of ICTs and especially the future of the Internet (its architecture and socio-economic fall out).

It must be acknowledged that no linear relationship exists between single technologies, technology trends, market and societal deployment of these technologies and socio-economic outcomes or impacts. The technologies interact among themselves and their deployment and ability to deliver impacts are determined by market forces, cultural factors, and pertaining governance structures, which shape demand and can determine technology lock-ins and break-outs.

Making any useful predictions about future development thus requires the use of scenarios The scenarios were built around governance, market and technology dimensions to capture competitive and collaborative forces, public and private interventions, as well as openness and interoperability of technologies. The scenarios set the parameters for modelling economic and social impacts by using the International Future's model. Outcomes of the modelling runs were validated by reviewing scientific literature, especially for social impacts. The analysis was complemented by a literature review on evolving business models and international policies.

Nevertheless, the report is structured as a consistent and essentially linear flow of reasoning, from emerging technologies, trough trends, and impacts, towards policies. To increase accessibility much of the discussion of theory and applied methodology is to be found in the appendices; thus the linkages among the intermediate steps from technology to policy are assumed. As indicated in the Interim report the linkages are based on an iterative process between various analytical steps to help gauge the uncertainty of future development. The Executive Summary is intended to help navigate the reader through these different parts of the analysis.

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Acknowledgment

The study team expresses its gratitude to all the experts who have contributed to this study, through interviews, workshop participation, methodological suggestions as well as thematic insights.

In particular we would like to thank the 'Economic impact of ICT' project led by the London School of Economics and the 'Social Impact of ICT project' led by the Universities of Siegen and Twente. In addition, special thanks are due to the EU KLEMS project and the developers of the International Futures Model under Barry Hughes.

The study team developed and organised the scenario workshop with Maarten Botterman of GNKS Consult, who has been an important contributor to the project. We thank Dr Fragiskos Archontakis for his contribution to the technology trend analysis.

Finally the study team wants to acknowledge the positive working relationship with the European Commission DG Information Society, and especially our project officer Morten Kristiansen and Head of Unit Ken Ducatel.

Thank you!

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Executive summary

This report was commissioned by DG INFSO as part of its preparations for the successor programme to i2010 – its current policy framework. It contains the results of the study of the socio-economic impacts of the 'Ubiquitous Internet Society' and its possible policy implications. The study contained a number of distinct but connected analytical steps; stringing together technologies that are supporting the trends towards a more connected world. These are linked to potential future socio-economic impacts and changing business models; as well as their likely policy consequences; in order to recommend a well argued set of actions within a consistent policy framework. This Executive Summary helps to support the reader in navigating between the various analytical steps of the report.

Connectivity Tech Trends

This study set out to review technology trends that relate to the notion of an emerging ubiquitous Internet Society – renamed in this study as 'Internet of X'. The trends or actually trend clusters that are identified in this study are:

- Development of a *Common communications infrastructure* – which can be accessed through different devices and technologies, removing sources of exclusion and discrimination, allowing the supporting technologies to 'draw in' new people and uses and put them in greater touch with one another. Technologies that are directly associated with this trend are: increasing bandwidth; increasing processing power and performance; Increasing electrical power and performance. Related technological development: the increase of internet capacity.
- Evolution towards *Computing as a ubiquitous utility* - putting computing on the same footing as water, power and telecommunications[1] and demonstrates the degree to which 'merely quantitative' advances on processing, storage, etc. develop qualitative transforming power precisely by being interconnected through the network. In addition, access to utility computing creates new demands for connectivity and reduces digital divides associated with differences in access to computing and storage. The mobilisation of shared computing resources seems likely to undermine the asymmetric 'client-server' form of connectivity in the same way that combined heat and power CHP) plants injected a stronger peer-to-peer aspect into energy connectivity. Technologies that are directly associated with this trend are: increasing

[1] Note that these are all regarded as utilities in the sense of universal service policy, but differ in the way they are regulated and the extent to which they may ultimately be regarded as suitable for competitive provision.

digital storage capability and decreasing cost per byte; faster computation; evolving computer architect; grid computing; cloud computing; everything as a service. Related technological developments are: open source software; more internet capacity.

- *The convergence of humans and computers - making* the 'ends' of the network smarter (e.g. through enhanced decision support), changing the need for active traffic monitoring and management in the network itself and producing new geometries of power and control. On the other hand, the electronic enhancement of human experience (e.g. via new input and output interfaces, etc.) creates a potential need for social connection – in the same way as advances in stand-alone platform-based computer games laid the foundations for today's on-line gaming and associated social networks. Technologies that are directly associated with this trend are: increased deployment of nanotech; cognitive computing; cybernetics, specifically cybernetic organisms; immersive virtual environments; decreasing size and increasing capability of embedded sensors. Related technological developments are: cheaper, faster and smaller RFID technology; more tools for personal identification and authentication; immersive virtual reality environments.
- The emergence of *the Intelligent Web: -* describing the deployment of existing technologies providing 'intelligence' to the protocols, structures and internal functions of the Internet itself, rebalances responsibilities and contributions of different stakeholders to overall socioeconomic impacts and creates a powerful 'pull' factor for further technological, economic, financial and social innovation. Technologies that are directly associated with this trend are: convergence of applications; more, easier and better creating & sharing tools; Web 3.0 tools. Related technological developments are: localisation of applications; decreasing size and increasing capability of sensors.

These are discussed in detail as to their nature, supporting technologies, key uncertainties, and likely governance aspects impacting the speed and trajectory of their development. Together they point at a future where people, objects and machines are more connected and context and location aware. This is a future where information flows automatically and can be used, exchanged, and accessed, from anywhere at any time with a great number of devices and interfaces. ICT's will disappear in objects, structures and even people. Moreover as ICT adapts to humans and becomes more intelligent and self-organising, people may become more like machines in the way they connect, behave, organise, and work.

Scenarios

These trends in themselves cannot be directly equated with certain future socio-economic impacts, as their deployment depends on the interaction among these trends and between these and governance and market factors. To gauge the possible future deployment and contexts for generating impacts three possible future worlds were built; representing distinct combinations of public vs. private governance, open vs. closed technologies and competitive vs. collusive markets. These dimensions were selected after careful review of literature and interviews with key experts in the field of ICTs and their role and interaction with society and the economy. The following scenarios were developed.

Scattered World (closed, private, competition); reflect a future of cutthroat monopolistic competition, unrestrained by active and effective antitrust and other regulation. It remains highly globalised, but the highly variable business and legal climates in different countries and sectors mean that network externalities, which might otherwise result in a 'tipping equilibrium' dominance by a few firms and/or technologies, never achieve global critical mass. By and large, individual users are able to find services and other offerings that meet their needs, though these are primarily mediated by market rather than collaborative societal forces. To meet the need for non-monetised communication and sharing, 'open-source' user communities thrive on the public and commercially-provided networks, but competition among platform providers ensures that these remain largely uncaptured by commercial entities. Government cooperation remains at a fairly low level of essential law enforcement and trade coordination, because national economic interests remain largely competitive and because active competition effectively forces firms to bundle solutions to societal problems (such as privacy and security) where it is feasible and cost-effective to do so. The fragmentation of competition and low levels of vertical and horizontal integration have as a counterpart low levels of inclusion and worrying levels of inequality.

Connected World (open, public, collaboration) paints a future where companies collaborate both domestically and internationally, facilitated by governments who take a cooperative lead in setting rules to optimise global public value creation. This public (-spirited) lead strongly reinforces open technologies so that firms have to compete (and make their money) on the merits of what they provide rather than the ability to exclude rivals. Indeed, interoperability and low entry barriers lead to a high degree of customization in individual applications; allowing customers and other civil society stakeholders considerable latitude to develop and satisfy diverse preferences. This interoperability is thus a powerful public good, and governments are particularly vigilant against the risk of foreclosure by 'bottleneck' firms or proprietary standards, using antitrust regulation, support for open standards and targeted public procurement to ensure a sustainably level playing field with high quality of service and reasonable prices. A potential limiting factor is that the speed of innovation – including the adaptability of policy to technological and market developments - is slowed by the natural pace of government initiatives (from negotiated rule changes to publicly-funded research and procurement). This world is very inclusive, including excellent technologies to assist those that need assistance to participate.

Borderless World (open, private, competition) depicts a world in which systems connect. It is basically a world where global standards emerged from a shake-out of less favoured standards, and are self-enforcing by virtue of strong customer and user preferences for products that connect to the enormous global investment represented by the Internet. High competition leads to low prices and high speed in terms of "time to market". Consumers have to rely on brands and social networks in order to be sure their choice is right: there is a clear private sector dominance in the way this world is run, and the focus is on profit rather than a broader concept of public value.

The scenarios are used in two ways:

1. As input to the formal impact modelling, using the International Futures Model (IFs): the scenarios correspond to specific parameter values, assumptions and outcome measures of particular interest

2. As a means to engage experts in a workshop context to discuss future policies: for this purpose the scenarios that were used for modelling impact will be further enriched with details, supporting data, and 'vignettes' of life stories in the year 2020

Each of the scenarios has been modelled using the International Futures model (IFs) to generate a range of socio-economic impacts. The outcomes were validated and complemented by a review of literature. These insights were applied to assess the effects on business models operating in the dawning ubiquitous Internet society.

Economic impacts

The economic impacts were mainly assessed in the context of the three scenarios as modelled in the International Futures model. A number of scenario dependent impacts were identified as well as a few more general expected impacts of the emerging Internet of X. General findings of likely future impacts are:

- Economic growth (at least in Europe) becomes increasingly capital-efficient. At the same time investment in the BRICs (Brazil, Russia, India, China) continues to outpace GDP growth, indicating that their real potential for economic dominance lies beyond 2025 and thus that Europe faces a long-term challenge in maintaining its strong position
- Multifactor Productivity (MFP) growth is held back by knowledge capital, meaning in rough terms that it attracts more payment than it deserves, possibly due to persistent market power in the control of intellectual property rights. Free access to ideas can reverse this as it makes visible the potential return to their shared exploitation. In addition, physical capital continues to retard multifactor productivity growth at the global level, although this is easing as new technologies reduce the deadweight loss of 'bottleneck' proprietary infrastructures. Finally, to fully asses productivity growth in the Internet of X, productivity gains in peer-based, open-source and other unpaid production also need to be accounted for, which is usually overlooked due to a focus on purely monetised returns.
- Growth of inequality within as well as between nations: will initially decrease in open and business driven economies. But as market power consolidates and prices rise, the poorest nations and individuals again begin to fall behind. Also, while governments in general are becoming less powerful (asymmetries of power among nations are weakening), the technological power of the leading countries is increasing. The situation of poorer nations can be partially ameliorated by a combination of stronger public sector engagement and greater openness (of technology and economic activity), which tend to promote a more sustainable and equitable society with long term decreasing inequality. As a result, interpersonal inequality increases in two out of three scenarios (Connected and Scattered Worlds).
- Greater connectivity and globalisation of financial and other markets tend to change economic dynamics. With strong public sector regulation (or effective self-regulation) this may promote short-run stability, but increase the chances of sudden (global) shocks in the medium term. Without effective regulation, complex short and medium term dynamics can produce sudden shifts in the availability of capital which in turn increases the volatility of expectations formation. This can produce either a sudden shift of capital to new technologies, business models or goods and services or a collective reluctance to abandon the status quo in favour of risky alternatives. Whether excess volatility or excess inertia

prevails depends strongly on recent history, making random shocks more persistent than they were before. In addition we note that GDP per capita understates the true social cost of the connectivity failure, given the likely higher rates of unemployment,

- With regard to economic policy, the combination of large shifts, global impacts, the availability of a wealth of real-time information and the possibility of using technology to implement sophisticated regulatory strategies can create an imperative for more active and continuous intervention. This can produce a fallacy of control; the growing *complexity* of the economy may render such actions less effective than hoped, generate a greater range of unforeseen consequences and possibly even contribute to economic instability (if authorities are too reactive) or inertia (if they become too risk-averse and therefore unwilling to stake political capital on policy changes whose consequences cannot be perfectly foreseen).

Social Impacts

Social impacts of the Internet of X were first reviewed within the (modified) framework set by another study funded by DG INFSO on the social impacts of ICT, and then applied to the scenarios and technology trends. Some social impacts like rationalisation, inequality, knowledge society index and connectivity were also modelled within the IFs to generate outcomes for Europe, Japan, Korea, America and the BRICs. In general one may conclude that technology does not determine social change. In fact it's the other way around. However in some areas behaviour is changing, or at least is changing at a faster pace, due to ICT and connectivity. There may be many overt and subliminal socio-economic impacts which over time affect values, governance structures and business models. Some of these impacts are:

- Rationality, intuition and beliefs (religious or other) are being rebalanced at the individual as well and the societal level. Professional instruments and networks provide some individuals with disproportionate influence, whilst also disenfranchising people who cannot use the tools or who feel overwhelmed.
- As with the economy, in the social sphere the growing complexity of interaction, the abundance of data (if not necessarily information) and the increasing salience of social policy may lead either to excess inertia or excess volatility. A reluctance to engage with complex changes can lead to gradual erosion of control,
- Bonding, bridging, and linking social ties are all relevant. Weak ties matter as much as – and for some purposes more than –strong ones. A world that encourages the formation and use of many weak ties may be more innovative – and more risky - than one that facilitates strong - and therefore less numerous and diverse -ties. More intermediation is expected to manage information streams and wide networks of social ties. Intermediaries may also get 'bottleneck' power because people cannot or will not bypass them, which may cause inefficiencies.
- Tech trends are likely to further blur the distinction between private and professional spheres, especially in combination with the emergence of a large group of "prosumers" (individuals acting both as producers and consumers, or migrating between the two roles as technologies and service offerings mature).

- Tech trends such as Utility Computing and Infrastructure Convergence offer platforms for bottom-up engagement with government and encourage policy making that is more actively driven by citizens and hence more responsive to their (direct) needs. This does not imply less public government, as strong public domain is important for allowing citizens, civil society and business – for better or worse - a platform or 'landing place' for active participation and involvement, without which empowerment through web 2.0 (and 3.0) tools and unlimited access to information will not be effective.
- The centrality of collaborative behaviour is likely to drive demand for soft skills and make them a central focus of education (notwithstanding the continued need for innovative engineering skills which are necessary for developing and managing complex technologies). Human-machine interfaces are likely to become increasingly intuitive, easy and less reliant on user (technical) expertise, as the tech trends such as Human-computer Convergence and the Intelligent Web move complex technical decisions from the end points to the centre of the network..
- Education is likely to become an increasingly critical national as well as personal asset if the job market of the future is as global as the flow of goods and services. Combined with Internet of X possibilities to deliver participative and interactive educational experiences as well as 'mere' curricular content, this may possibly lead to dominance of 'branded' education provided by (commercial) elite institutions and thus increased inequality of access and skills. Other potential impacts include limited access to skilled positions by those with 'second tier' skills and loss of intellectual diversity.
- The European Research Area concept aims both to produce a richer set of research outputs and to increase individual incentives to develop human and social capital. The same approach can be applied to the educational 'strand' of the educational establishment to induce students to benefit from the rich supply of education across Europe through common standards and joint educational programmes. Without such rationalisation there may be over-supply of education without sufficient variation.
- Work and careers will develop (at the higher skill levels, at least) a portfolio character, which will increase the resilience of individual employment to changes in the labour market and internalise much cross-cutting or 'tech transfer' innovation. Large global companies will invest more in attracting than in retaining talent and skills. A by-product will be the emergence of online (public and private) services to enable workers to manage their own training and social security across Europe and possibly globally.

Business model impacts

How business models change depends largely on market structures and governance. Therefore their development is very sensitive to the differences in the scenarios. In contrast strong public governance is likely to use competition law more actively to break up monopolies and undesirable technology lock-ins. A strong market driven dynamic may lead to global monopolies but also possibly to more integrated service offerings. An important distinction that needs to be made in assessing business models is the extent to which they achieve value capture or value creation. From a public policy perspective the second is likely to be the more desirable. Some of the impacts that were identified are the following.

- In general, technology trends that preserve Internet openness are seen to favour net value creation, while those that enhance proprietary restrictions and reward lock-in favour net value capture as a rationale for business model evolution.
- Dominance of global business brings certain benefits of integrated service offerings based on proprietary standards, leading rival firms to favour incompatible products, thus limiting customer mobility. This may threaten diversity and competition due to technological lock-in and rent-seeking behaviour. Such behaviour would seriously impede small innovators' ability to enter markets as the incumbents aim to capture as much value as possible through technology lock-in at the infrastructure and platform levels or through coercing innovators to join existing IPR and interoperability clusters.
- A counter trend may well support many small suppliers of services to the platforms. As the dominant companies seek the speed, creativity and volume of large and diverse populations to develop (e.g. crowdsourcing) and to consume (e.g. the long tail) new formats and applications for their platforms, they are likely to embrace openness.
- Firms whose business models depend critically on the ubiquity, quality and affordability of communication infrastructures will increasingly try to influence the platform market. This will be opposed by platform providers in so-called 'two-sided markets' who will try to exploit the complementarity of content and service providers with end-users and consumers. Increased functional substitutability among infrastructures would reduce this effect and would be likely to make infrastructure service providers abandon business models based on vertical foreclosure for more competitive, utility provision models.
- In principle, utility computing decreases the advantage of large firms and increases the ability of consumers to take control of and exploit their own profiles (including activity records and other personal data). Human-computer convergence will strengthen this trend as it also enables a high degree of customisation. However the effect is likely to be different as Human-computer convergence will almost inevitably complicate customer switching. It does this by enabling the provision of an increasing range of 'niche' services suiting the specific characteristics of clients.
- Innovation is likely to become even more important as the basis for commercial success shifts away from commoditised offerings or as commoditisation and homogenisation are pushed down into the infrastructural layer. Differentiation and divergent innovation will be stronger in the user-facing layers. Innovation is also likely to become more 'democratic', with companies striving to promote endogenous innovation, using the stronger (internal) connectivity of creative individuals, customer feedback
- The services will be increasingly paid by licensing and less by advertising. New technologies and business models allow greater discrimination and differentiation in pricing, quality of service, content and other aspects of valued services. Because these are valued differently by different people, and because their provision triggers joint as well as separate costs (e.g. infrastructure costs or congestion/contention costs), some form of discrimination is necessary for profit maximisation and for efficiency and equity.

Policy issues

To identify policies that would deal with future issues, experts were asked to engage in a scenario game. They were asked to identify the key policy issues through a SWOT analysis of the three scenarios. They were then asked to look back from the future and identify policies that would have dealt with the issues to achieve more desirable outcomes. The feedback from the three groups was processed and reworked into a new scenario. The same group of experts was asked to engage in a role play of citizens/civil society, business and government decision makers to identify the critical issues and remedies from these distinct perspectives. Both exercises together allow identifying issues and policies that are sensitive to stakeholder interest and which are able to perform under deep (future) uncertainty.

The issues that emerged can be categorised under five sub headings: core values and principles; architecture and design; uncertainties; leadership and coordination and policy instruments. The most relevant issues are summarised here:

- *Core values and principles*

A review of the concept of privacy and the means to protect it. Some form of fundamental right to privacy will still exist in 2020; either government driven (data protection frameworks), business driven (self-regulation, privacy at a premium), or citizen driven. A future proof approach is likely to be more risk based and outcome oriented; guided by general privacy principles, including stronger personal liability and redress instruments. Technical measures would be an important part of privacy protection. The user will be in control, permitting revocation and legal control methods, maybe in combination with data stewardship.

The importance of trust. Trust is a multi-stakeholder concept, in which governments (especially in a global context), will no longer be the final arbiter. Hierarchical, top down approaches conflict with the end-to-end principle[2], requiring a more equitable partnership (peering) between actors. Trusted environments will be enabled through transparency, provided through technological solutions and embedded in legal frameworks. In case of trust there is a trade off between open and closed networks, in which (private) Trusted Third Parties (TTP) could be an intermediary.

The central concept of identity – group and individual. Individual and group identities are central to the functioning of society and the behaviour of individuals and collectives. Identity capital ties past circumstance and behaviour to current choice and future consequence and remains the most important intangible asset of the Information Society. The Internet poses a new threat to individual identity, by making it more fragmented and less durable or private or by weakening the constraints that help align individual and group interests. This raises questions on the level of privacy and autonomy individuals will retain, on how they may influence collective action and group reputations and how individuals will form, join and leave groups.

- *Architecture and design*

The benefits of open networks and how to ensure this; including Net Neutrality There is a trade-off between requirement for data protection and the value of using information for innovations in an open network. The world of 2020 is expected to allow for differentiation by quality of service. In light of the Net Neutrality discussion it is thus expected that pure

[2] See footnote 4

indiscriminate openness will give way to a more hybrid situation of fully open networks for basic services and quality of service (QoS) models for premium offerings.

Interoperability, connectivity and the architecture of networks. Most ICT solutions could be IP based or use other open protocols and standards; however this is rarely in the interest of dominant market players. The challenge will be to keep the architecture whole and coherent if you move for a network with more 'intelligence' built in. The report notes the distinction between 'horizontal' (connecting ends without platform) and vertical connections. If horizontal interoperation –is limited, then consumer mobility, competition and 'bottom up' innovations are limited. *Vertical interconnectivity*[3] is concerned with technical, organisational, price, and other barriers. The legal and economic basis for promoting interoperability may differ by kind (technical, organisational, economic, etc). Any assessment of possible interventions for increasing interoperability must start by identifying when interoperability is good and when it is bad, and for whom it is good or bad. But also, who can be regulated or subsidised and how static and dynamic considerations trade off against each other.

Open Standards. Interoperability and open standards - are part of the same issue[4] Open standards apply in one way or another to all tech trends: allowing the 'higher layers' to maximise benefit from the converged infrastructure layer; allowing the 'cloud' to find an optimal architecture; facilitating diversity of innovation in new forms of human experience enhancement, increasing the reach of cybernetic systems and enabling participation; and finally allowing 'smart' elements of infrastructure management to be deployed across a range of interacting systems

The extent to which public good services/controls need to be deployed inside the network. The end-to-end principle either needs to be reconfirmed and strengthened, or reviewed, possibly by putting security and other 'public good' controls in the network. This is beyond the remit of the EC, but it may research practices of ISPs, and the technologies and use of deep package inspections. Also the EC can help broker an EU vision on the risks and benefits and articulate a new concept of controlled openness.

- *Uncertainties*

In 2020 we will need to be able comfortable with uncertainty, to deal with 'Black Swans', disruptive technologies and creative destruction.

Availability of and access to new infrastructures (incentives to invest). It is uncertain who will invest in new generations of infrastructure and what model will prevail. A basic principle *might* be to separate the construction (and operation) of physical infrastructures from the (potentially) competitive provision of services over the infrastructure, possibly involving (partial) state ownership of the infrastructure. Restrictions and inefficiencies of existing infrastructure governance may contribute to the growth of alternative infrastructures and to market segmentation, which may be discriminatory and undermine the infrastructure convergence trend. Facilities-based competition experienced in Europe has led to a misallocation of traffic among these modes (compared to their technological strengths and

[3] This is largely covered by existing frameworks involving 'essential facilities,' critical infrastructures, common carriage or easements;

[4] See also for a discussion on open standards: Undheim 2008

weaknesses) and thus distorted uptake and the development of services and applications in other parts of the value chain.

Competition and the risks of technology lock-ins. The interconnectedness of the Internet of X challenges competition as the sustainable engine of continual improvement. Network externalities favour 'tipping' into monopoly and competition weakens or moves to the extensive margin, with firms striving to produce as much variety as possible. Such variety may stem more from a desire to limit interoperability than a desire to innovate and offer effective choice. Lock-in can be good or bad. Technology, market and societal structures and norms of behaviour can be self-reinforcing even resisting superior alternatives. An early advantage can be sustained by cohesion, allowing time for collective benefits to develop. Policy should take this 'stickiness' or path dependence into account, for example by: consumer protection or other policies that protect users and enable them to escape harmful lock-in.

- *Leadership and coordination*

Horizontal nature of connectivity and the role DG INFSO can play as an expert centre or catalyst inside the EC. Future Internet policy has a cross-cutting nature and connectivity touches on almost every aspect of Information Society development. Therefore connectivity aspects should be taken into account in formulating all EC policies (connectivity awareness). INFSO should inform and support thematic DG's in their understanding of the emerging 'Internet of X' and how this affects their policy areas; also through connectivity-based monitoring tools for impact assessment and policy evaluation.

Need for public leadership in setting the EC agenda and influencing global ICT/Internet policies. The Internet of X will be largely global. Policies and ambitions should reflect this. The EU (still) has an opportunity to influence the value setting of these global phenomena in global fora. Since the financial crisis - rooted in an increasingly connected financial system - connectivity is becoming politically more important. The EC is in a good position to lead, facilitate and mediate the investment in high bandwidth infrastructure and linkages across borders.

- *Instruments*

Multi-stakeholder networks and governance principles. The EC can encourage efficient competition among technologies and discourage inefficiently-high incompatibility, through creation or coordination of multi-stakeholder platforms and networks, and by applying multi-stakeholder governance principle. These would be enabling the adoption of common standards and market wide approaches to public policy concerns. The challenge is to intervene in a way that replaces inflexible 'black-letter' prescriptions with mechanisms that help identify the best approach and engage the efforts of those best-placed to help it.

Technology as a complement of traditional policy tools. The use of technology as a complement of traditional policy tools like regulation may hold promise for ensuring public interests where self-regulations is too weak and regulation cannot be enforced or is too inflexible and slow.

Supporting 'self-correcting' market mechanisms. Policy solutions should seek to exploit and support 'self-correcting' market mechanisms (Quality of Service/Net Neutrality, spectrum trading, etc.), where necessary backed up with the threat of regulation. In the virtual world of the 'Internet of X' traditional regulation will have limited traction and will be difficult to enforce. Therefore the EC should further analyse how best to structure self-regulation, and mitigate the risks.

Better and more strategic use of procurement. For a number of reasons the huge potential of procurement for creating a technology and innovation pull remains under exploited, with cross-border procurement still only representing 15% of overall public procurement.

Spectrum allocation as powerful ex ante *tool.* Traditional ex ante regulation and ex post control of the wireless domain is increasingly difficult. Spectrum allocation can be a substitute (*ex ante*) policy instrument to support innovation, new technology, and more competition. However the use of auctions has lead to mixed outcomes in balancing different policy objectives (technical, economic, and societal) and much available spectrum is hoarded or left idle. Allocation mechanisms are shifting towards a combination of market-based regulation, societal regulation and 'regulatory withdrawal'. The EU may monitor the effectiveness of these mechanisms and also support policy convergence and standards to support a strong internal market for hardware in Europe.

International comparison of policies: Japan, South Korea, United States, Canada and OECD

Before recommending specific actions based on a theoretical exercise and the outcomes of a scenario game, a review of policy frameworks in the most advanced and connected countries was conducted. This allows assessing and comparing the most recent global policy thinking about how to address the connectivity challenges and the socio-economic impact of the Internet of X.

- The development of a future ICT strategy is still very much work in progress in all countries. With the exception of the OECD, there is no fully developed ICT strategy for the time frame 2010-2020.
- Early thinking about a future ICT strategy seems to revolve in all cases around the idea of a ubiquitous network society. Particular emphasis is given to the positive societal impact associated with such a society – but also potential threats (such as increased internet addiction or concerns of privacy, accountability and freedom of action) are articulated.
- In terms of leadership, ICT strategy development and implementation are ranked highly on the agenda of most countries – as is reflected in the engagement of policymakers at highest political level in these countries.
- Despite agreement on the objectives and ambitions of a future ICT strategy (in the early thinking) there are significant differences between the different countries (and the OECD) about how these are best to be achieved. These differences range from differences in the role of government to differences in further technical development. In particular US and Japan are developing a new networking and distributed systems architecture that is meant to revolutionise computing, while South Korea, Canada and the OECD focus on the upgrade of the existing net architecture (from IPv4 to IPv6).

Recommendations and policy framework

The ultimate objective of this exercise was to identify and recommend policy actions to the European Commission. Through a scenario workshop, in which the virtual hindsight technique was applied, experts were engaged to think of adequate policies to respond to the future challenges of the Internet of X, enhancing opportunities and mitigating the risks. These and further reflections on the complexity of networks and the challenges raised by connectivity have lead to suggestions for an overarching policy framework for the European Commission and DG INFSO in particular. The framework identifies the vertical – or DG INFSO specific – policy themes, as well as linking areas across the Commission where connectivity plays an important role. Additionally, the framework identifies areas beyond the reach of DG INFSO that are critical for ensuring good and/or bad connectivity. Finally some policy instruments have been suggested.

Introduction

Objective

This report suggests a policy framework for addressing the future challenges of the 'Ubiquitous Internet Society' or as we dubbed it: the 'Internet of X'.

The Internet of X encompasses concepts like the 'Internet of Things, of Services, and of People. In short, this is a world where people, objects and machines communicate seamlessly, where the human-machine distinction fades and where surroundings are embedded with computing power, creating intelligent environments, supported by converged infrastructures.

To identify policies for addressing the challenges of this future we need to understand the underlying technology trends (including their constituent technologies) and what mechanisms exists to generate socio-economic impacts. These mechanisms are described as the dimensions of a scenario space in which technological, governance and market factors delineate possible futures. We have assessed the way technology trends interact with these futures to generate socio-economic impacts and to affect the success of current and future business models for the period 2010-2020.

Approach

The challenge of the study was to approximate the possible relationships among specific technologies, aggregate them into functional "tech trend clusters" and analyse the extent and significance of their market and social deployment, and their subsequent socio-economic impacts and outcomes. We recognise that technology trends are at least partially responsive to socioeconomic developments, but we are starting with them as initial drivers, returning to their causation in the scenarios. The approach taken is thus to:

1. identify a limited set of technology trend clusters based on a review of technology foresight literature and key informant interviews.
2. conduct a detailed analysis of the supporting and associated technologies in terms of those drivers, barriers, key uncertainties and governance factors likely to affect trend development
3. map these along a set of technology, governance and market dimensions that will affect the speed and nature of trend development and deployment.
4. build a small set of scenarios for the year 2020 using the same dimensions to explore the possible development of tech trends and socio-economic impacts

5. assess those impacts in the context of the scenarios through use of the International Futures Model and review of relevant literature on the relation between ICT deployment and societal and economic indicators. A separate review was conducted to project the impact of the tech trends on business models.
6. run a scenario game to engage experts to think about the scenario worlds; identifying strengths and weaknesses, threats and opportunities. Then developing policy responses with the benefit of virtual future hindsight (i.e. what should we have done in 2009 if knew then what we know now in our 2020 world?
7. review international policies to inform the European Commission on ongoing activities in the US, Japan, South Korea and Canada.

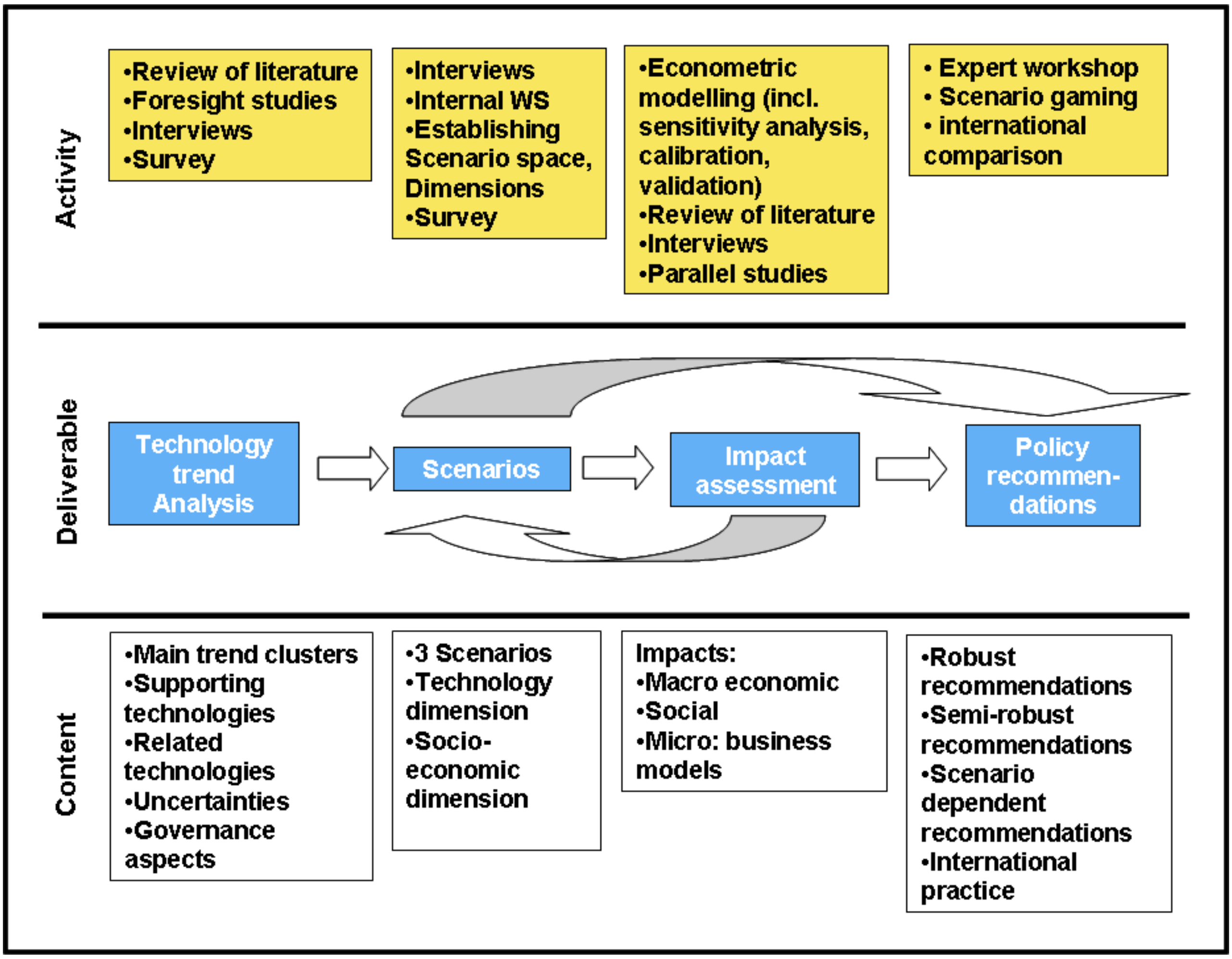

Figure 1: Study flow

The report is structured as follows:

Chapter 1: Analysis of Technology Trends, discussing each of the technology clusters and their supporting technologies, key uncertainties and governance aspects

Chapter 2: Projecting the future: Scenarios for tech trend development and impact assessment. In this chapter the scenarios are developed and described that will be used for the remainder of the study to project possible socio-economic impacts and policy responses.

Chapter 3: Impact Assessment: Economic, social, and business models. This chapter identifies impacts of the Internet of X and projects possible consequences and developments in the next 10 years.

Chapter 4: Policy Implications of the Internet of X, This chapter lists and describes the critical current and future policy concerns based on the results of an expert scenario gaming workshop.

Chapter 5: International policy comparison: US, Japan, Canada, and South Korea. This chapter compares the EU to its international benchmarks and reviews the state of policy making in relation to the future Internet of X,

Chapter 6: Recommendations: A policy framework for the Internet of X. This final chapter draws conclusions from the analysis to recommend a policy framework and a suite of individual policies and approaches in response to the emergence of the Internet of X.

CHAPTER 1 Analysis of Technology Trends

The trends result from combined development of many different technologies. These are organised into four clusters for ease of analysis, but also because forecasts of specific technologies are both far less robust and less relevant for impact analysis than projections of the developing functionality enabled by those technologies. These clusters are all aspects of a central technology trend, the emergent 'Internet of X,' which combines e.g. the "Internets of" Things, Services, people, organisations, etc. Summaries of the trends are provided below and condensed tables can be found in Appendix A: - for each trend we briefly provide:

1. Description of the trend
2. Directly associated technology trends
3. Closely related technology trends
4. Key uncertainties
5. Governance aspects

The technology clusters are not independent – Utility Computing depends on the common infrastructure and provides a strong incentive shaping Infrastructure Convergence; shifting human-computer integration will reshape the locus and nature of distributed intelligence in the web, etc. Therefore, in order to understand the structural, behavioural and impact implications of the Internet of X it is necessary to relate the clusters to each other in a common framework. Because the trends are not independent, not all combinations are equally possible, feasible or even likely. Thus the classification of cluster trends characterises the Internet of X.

1.1 Defining the Trends

Technology trends as used in this project represent a clustering based on specific technology characteristics, functional requirements, and socioeconomic impact mechanisms. This was preferred to a pure technology foresight method for several reasons. One is the impossibility of precisely forecasting specific technologies over the timescale addressed by the project. More important are the non-linearities linking innovation with impacts; technologies emerging from formal research certainly shape market development and demand (as end-users learn to exploit new capabilities), but emergent user demands and bottom-up innovation feed back to determine the areas of technological development that are pursued or reach deployment. Moreover, significant spillovers among complementary technologies and market developments lead to critical mass effects and complex system phenomena such as emergence and synchronicity (clustering in functionality and time). Finally, technology, market goods and services and socioeconomic impacts have different natural granularities. To put it simply; yesterday's technologies shape today's services and tomorrow's socioeconomic impacts; yesterday's services shape today's socioeconomic impacts and tomorrow's technologies; and yesterday's socioeconomic impacts shape today's technologies and tomorrow's services.

To provide a clear and evidence-based starting point for identifying useful clusters, we began with technology trends identified on the basis of a literature review followed by a cluster analysis. The literature review started from 24 current technology foresight studies. These were supplemented by a review of policy, trade and popular press documents to identify socioeconomic implications of identified technologies and add associated technologies. The technologies were organised into functional clusters[5]. The analysis in the foresight studies and secondary references was then synthesised to identify 12 overall 'technology clusters' - areas of technology development viewed from a functional perspective:

1. Convergence of infrastructures
2. Human Computer Convergence
3. Pervasive or Ubiquitous Computing (Internet of things/services, RFID, geospatial services)
4. The Intelligent Web
5. Personal Identification and Authentication
6. Evolution of social networks
7. Data Management
8. Convergence of applications
9. Mixing of Real and virtual worlds
10. Artificial Life and Artificial Intelligence
11. Increased requirement for better performing services and emergence of new business models
12. Nomadic Use and Seamless connectivity

For each, we analysed the drivers, obstacles/barriers, critical uncertainties and associated business, economics, legal and societal impacts. These were scanned for common elements that could be used to cluster the technology trends; connectivity emerged as the dominant theme. It should be stressed that the process began with technological, economic and societal

[5] e.g. storage; computation; sensors; display; 'wetware' (human inclusion in cybernetic systems); nanotechnology; communications - signal transport, switching, traffic management, packet inspection, etc.; wireless access; grid and cloud architectures; language technologies; etc.

description of the broad sweep of technology, and not from the four main trend clusters used in this study; they were the output of the process. The clustering was approached by way of the enablers representing important and sustainable developments across the technological, economic and societal spheres and the critical uncertainties associated with each sphere (summarised in the discussions below).

Finally, it will be noted that the selected technology trends form a subset of those listed above. This was a natural outcome of the emphasis in the study on the *combined* technological;, societal and economic impacts associated with the trends, the focus on connectivity as the key characteristic and the identification of complementary dimensions along which to organise the technology trends (openness and variety) and their socioeconomic impacts (public/private control and cooperative/competitive interaction).

1.2 Trend 1: Infrastructure Convergence (toward a global information infrastructure)

1.2.1 Trend description

This "trend cluster" describes how different technical methods of communications primarily are converging into a single 'information infrastructure'. 'Convergence' can mean different things; while it is certain that convergence (in technical, economic and societal senses) will continue, it is less certain what form this will take. We need to consider the degree to which infrastructure is interconnected and how its parts interoperate, whether they perform the same or different functions, whether they are used by the same or different entities, and thus whether they offer equivalent, equitable or equal capabilities in any meaningful sense.

Perhaps the most compelling vision is that of a 'flat' common infrastructure in which differences in technology are largely invisible either because they are not relevant to users or because the system somehow chooses the 'best' technology for each purpose. This vision is characterised by seamless connectivity and minimal distinction as to what can be done with different devices. No longer will use of a mobile phone restrict surfing to specific mobile-friendly Internet sites or a use of a TV set to viewing broadcasts from a single provider.

A single global information infrastructure is not just about the pipes or wavelengths carrying the communications, but also the associated infrastructure. The challenge to providers is increasingly to deliver the 'feeling' of seamlessness, simplicity, comprehensive reach, etc. to end-users interested in wandering all over the network. One way is to adopt common protocols, etc. – but this risks exposing your users to rival offers or letting them strike out on their own. Thus a wide variety of practices to manage competition have arisen.[6] To date, the prevailing approach has been neutral - such nodes in the infrastructure are increasingly

[6] Some of these are based on specific technologies or are technologically enabled via Access Points, Exchanges, landing points, Peering co-locations and Points of Presence, base and transmitter stations etc.

configured to converse in a range of data languages or protocols and to switch seamlessly from wireless to wired interfaces. In addition, they are designed to be scalable[7] and robust.

This approach is to some extent an artefact of the relative abundance of bandwidth and may change as demand leapfrogs supply. In a congested net, IP may be too ‘flat’ to permit efficient allocation of scarce transit capability to different uses, but traffic-shaping, flex-speed and dedicated uncongested ‘pipes’ (like fibre to the home/curb/cabinet) can provide different sorting mechanisms. In such a crowded network, reliability and robustness are increasingly important, so any protocol or traffic management system (including IPv6, which provides more addresses but increases the load on switches, etc.) forming the rules of the road for data communication via this infrastructure must be robust enough to handle natural or man-made shocks or incidents.

1.2.2 **Directly associated technology trends:**

Increasing bandwidth A wide variety of new and evolving physical and data transmission & transport technologies have characteristics of greater and greater bandwidth.[8] The impact of these new technological advances is that the restrictions upon interaction with content on any device at any time are removed. Increased processing power and performance also enables the ‘delocalisation of content’ - freeing access to a broad range of content from uncertain reliability, variable quality of service and restriction to specific locations and/or platforms. This liberates users from the power of schedulers, and thus also reduces the productivity of schedule-based advertising, which is an essential element of the traditional broadcasting business model. It leads instead to alternative models (like targeted click-through advertising) based on greater interactivity. The regulatory relationships built on 'broadcast' and other scheduled services is likely to be weakened

Increasing processing power and performance Through the advent of 45 nm design, bubble memory, quantum computing, etc processing and communicating power development is running ahead of Moore’s Law. Increases in computing power allow computing and content manipulation to be provided as services. They also increase the capability of the system as a whole to manage capacity loads, traffic prioritisation, security and other functions more efficiently and effectively. The one-size-fits-all approaches and permissive stance associated with the end-to-end principle[9] have proven inadequate to provide protection *and* functionality, as network environments become more complex. It needs to be noted that

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[7] Note that the Internet as it has evolved has the character of a complex adaptive system, made by connecting component systems that are (relatively) complex and diversified. As necessary system functions become more complex (e.g. security, privacy, traffic management, etc.), user demands for functionality increase ()see Computing as Utility technology trend cluster below) and a greater proportion of routine traffic involves movement of large blocks of content, the self-regulatory character of the Internet may erode. (See discussion below on reconsideration of the ‘end-to-end principle).

[8] Current examples include fibre-optic cabling (especially fibre to the home - FTTH) *DSL, Ultra Wide Broadband (UWB) and new and rapidly evolving wireless technologies such as LTE and WiMAX

[9] Formally, this states that states that, whenever possible, communications protocol operations should be defined to occur at the end-points of a communications system, or as close as possible to the resource being controlled. It was originally used to provide rules on where *not* to put functions in a communication system, but it has evolved to address issues of how to maintain openness, increase reliability and robustness and preserve properties of user choice and ease of new service development. (see e.g. Blumenthal and Clark (2001) and discussion on page 19).

increased computing power in end-user devices may exacerbate 'digital divides', while enhanced functionality of the common infrastructure tends to reduce them.

Increasing electrical power and performance The Internet runs on electricity; access to reliable power has limited the functionality, mobility and uptake of its possibilities, especially as energy density of devices and reliance on dependable supplies have increased. This is exacerbated with the growth of societal dependence on the Internet[10]. An important technology trend in this respect is the greater efficiency of new generations of battery and energy storage technology, such as current lithium-ion technologies. These permit devices to consume significantly less power over the same or more time when compared to their predecessors. Other near-to-market power technologies are also going to have an impact, such as energy generation to be built into everyday objects so that, for example by placing a mobile phone on a desk embedded with this technology, it recharges without the need for a plug or specific adaptor (working at a specific voltage or current). It is also increasingly possible to use 'free' sources like physical activity (imagine a computer run by the power expended in striking the keys). The combination of greater computing power and lower electrical power can lead to a qualitative change in their autonomy and contribution to overall system function. With modest increases in 'intelligence' nanoscale devices can begin to play more active roles in improving the functionality and utility of the objects in which they are embedded e.g. as intended by designers of the 'smart' objects ranging from the micro scale (smart clothes) to the macro scale (smart power grids) that will increasingly dominate the population of the Internet of X. However, beyond this level of functionality, they may develop a degree of autonomy that raises serious ethical (e.g. relating to responsibility and informed choice) and practical questions (e.g. relating to the good and bad emergent properties of complex systems) that have received only limited attention to date[11].

The availability of greater computing power at lower electrical load weakens connections between Internet access and functionality on one side and the built infrastructure of buildings, etc. on the other This type of 'ubiquity' tends to make the Internet even more essential (though there is room to substitute local for remote processing power). However, increasing emphasis on ubiquity confronts the Internet infrastructure with entirely new demands and requirements, whose highly disaggregated and often microscopic scale may make their combined impacts hard to plan for or accommodate.

1.2.3 Closely related technology trends

More internet capacity A further technology trend related to this cluster is the expansion of Internet capacity via improved bandwidth and reach. This increase in *scale* will permit the threshold barriers to optimising socio-economic benefits to be overcome, and thus provides incentives for large infrastructural investment and roll outs. This is mainly accomplished by technical implementation of standards and commonly accepted approaches, running from the clean-slate end of the spectrum (for example, IPv6) to temporary patches. Within this spectrum lie various standards to help backbone Autonomous System (AS) providers (those

[10] It is for this reason that telephone services are provided with their own power supplies, to ensure continuity of communications in the event of a disruption to the power supply. To date, the Internet analogues have no analogous fallback.

[11] See e.g. http://news.bbc.co.uk/1/hi/technology/8210477.stm

at the top level of Internet topography) communicate and peer with each other in a robust, scalable and transparent manner[12]. There is an apparently-robust trend toward convergence upon Internet Protocol (IP) as the preferred packet-switched transmission and control protocol for an increasing range of services. It remains to be seen whether IP will retain its dominance or give way to a cyclical proliferation of different protocols (such as IPX, Frame-relay or ATM).

1.2.4 **Key uncertainties**

Trend-breaks

- One uncertainty is *access to capital* for funding large infrastructure roll outs. Whilst debate continues as to whether the existing economic situation represents part of a normal cycle or something more serious, the prospects for private access to capital, and the impact of economic stimulus packages[13]; this remains a key uncertainty.
- It is not obvious to what extent the evolution of the Infrastructure Convergence will be characterised by ubiquitous *interoperability* (open-closed) and (public or proprietary) global standardisation. These in turn will influence the course of economic and policy globalisation.
- The fate of *energy and environmental policy*; in particular whether it will favourably affect the development of more efficient power and energy consumption technologies and how such improvements will manifest themselves.[14]
- The extent to which *wireless technology will displace* (rather than complement) *wireline technologies*, with the accompanying changes in infrastructure as well as socioeconomic impacts. In this regard, the emergence of symmetric (e.g. LTE) or asymmetric (e.g. WiMax) wireless technologies and the allocation of spectrum towards their further development could stimulate a wholesale shift to wireless communications or to hybrid fibre/wireless architectures in which the power of fixed-line Telco's may be greatly reduced.
- The *continued effectiveness of large powerful corporations in setting favourable standards* and the wider *effectiveness of standards bodies* generally.
- Finally, the *ownership and effective control of this infrastructure* is a vital uncertainty, especially in relation to socioeconomic impacts. If public ownership or virtual public control via universal service requirements, etc. dominate, it is reasonable to expect both a greater degree of autonomy from commercial forces and mandated levels of open access, transparency, etc. At the same time, public control of investment returns may inhibit

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[12] Current examples include various iterations of Border Gateway Protocol (BGP, currently in v4) and technology to switch traffic between different protocols (common over carrier backbone providers) – a current example of this is MPLS (Multi-Protocol Label Switching).

[13] It has been noted that major public infrastructure projects formed an essential part of the recovery policies following the 1929 Great Depression.

[14] For example, the increasing energy-density and environmental footprint of ICT equipment (and the rapid pace of obsolescence) undercut, if not reverse, progress towards 'immaterialisation' – substituting communications for travel and information goods for physical goods. This term was used in a variety of DGINFSO projects on the sustainability of the Information Society (e.g. ASSIST, TERRA2000, SASKIA).

investment and roll-out without public subsidy (directly or via regulatory protection) or by the sharing on a global scale and across all service providers of the associated costs, perhaps via an international universal service requirement set by a global body such as the ITU that mandates companies to roll out such infrastructure.

Socio-economic aspects that might affect this trend include the *continued dominance of urban living*, familiarity and appetite for telecommuting and more generally demand *for content rich data streams* (perhaps encouraged or driven by the Intelligent Web trend cluster and the availability of storage in the 'cloud' as described in the 'Utility Computing' trend-cluster). Globally, too, the ability of other nation-states to leapfrog costly investment in fixed infrastructures and transition smoothly from voice orientated wireless to data could help to spur this trend to become truly global.

1.2.5 **Governance aspects**

A number of policy issues are related to this tech trend cluster, even though they have relevance for the other clusters too. These issues and the possible responses to them, impact on the development of the convergence of infrastructures:

- Requirement of *ex ante* evaluation of the likely impact of policy to effectively achieve openness or diversity to choose among alternative policies
- Assuring access to the infrastructure by service providers and access to services by end-users.
- Balancing wide choice of platforms and technologies, with simplicity, effectiveness and control

Beyond policy aspects that encourage the growth and integration of the infrastructure, successful convergence also requires access to the infrastructure by service providers and access to services by end-users. Thus, stimuli to investment, innovation and competitive infrastructure provision are likely to be complemented by *access regulation* (e.g. spectrum auctions and interconnect/settlement policy) as well as more general *competition and consumer protection measures*[15]. These policy levers will operate across a range of hierarchies, including national governments (e.g. in national policies to stimulate the roll out of infrastructure) and international fora (such as the ITU and ISO/IEC.

The deployment of these technologies and the associated trend towards a common infrastructure is governed more by choice than compulsion; choice of company to deploy these technologies as market opportunity dictates and consumer choice among the platforms they use to connect to this infrastructure. Given ubiquitous connectivity, these choices may vary rapidly. The drive to open things up (and to exercise wide choice) is countered by the struggle (by commercial, government and some civil society entities) to enclose, to simplify, and to narrow the range of choice.

Overall, in a world of convergence, 'ownership' of the converged 'patchwork quilt' infrastructure cannot be given to a single utility provider, This in turn requires different

[15] There is a more general need to continue the re-examination of the telecom regulatory framework and its linkages to other policy instruments, but this is not limited to this (or any) technology trend, and should be discussed elsewhere.

types of regulation compared to the classic 'public utility' relation between a single regulator and a single infrastructure provider.

1.3 Trend 2: Human-computer Convergence (Computing on the human platform)

1.3.1 Trend description

This trend cluster reflects the steadily increasing linkage of human and ICT activities; the intertwining of biological forms and ICT in a number of ways including in the physical and cognitive state (and also perhaps sometime in the future, in the emotional or conscious state). In essence, this linkage runs in two directions:

1. Closer integration of ICT into human decision and support systems and Models for ICT systems architectures (cognitive computing).
2. Use of human (biological or social) systems as modular adjuncts to automated systems (cybernetic organisms and social computing)

This trend is concerned with *cognitive* convergence as well as *physical* convergence of humans and computers. This is reflected in technologies that permit automation and delegation of human decision-making to ICTs. These decision support systems can vary from simple software agents or code that identifies behaviour based on past choices, to proactive agents that search, locate, identify manage and use all sorts of resources based on known or predicted parameters about user choice or preference. There are more sophisticated systems that take advantage of the useful functionality and characteristics of ICTs (speed in processing a large amount of data, rapidity in decision-making, automation etc). The logical extension of this is the predictive, rule based logic of ICT taking decisions to before the intervention of the human is necessary (or even conceived). Of course, such systems must at a minimum be robust to (and more generally try to accommodate, enhance and exploit) human errors, mistakes and intuition.

This trend cluster also covers computing *about* the human platform and the autonomous collection, processing, storage and retrieval of vast quantities of data about humans and their environments, including e.g. biocomputing, which has spawned new ways to process and analyse biological and behavioural information about living systems. Other elements of this trend cluster include the emergent developments in Artificial Life (AL) and Artificial Intelligence (AI). The latter is of particular interest given its (relatively) realistic timeframe in terms of practical application. Finally, the outcome of this trend cluster will be an explosion in the nomadic (mobile computing and access to personalised computing space from any terminal) use of computers, enabled by the trend clusters seen in the growth of the single global information infrastructure.

The trend cluster can be identified across a wide spectrum of human-computer interaction (itself a rapidly-growing field or research across many disciplines). Many aspects of this trend were identified since the early days of computer use[16]; and most drew attention to the blurring boundaries of humanity. As Norman Cousins pointed out in 1966[17]:

> *The question persists and indeed grows whether the computer will make it easier or harder for human beings to know who they really are, to identify their real problems, to respond more fully to beauty, to place adequate value on life, and to make their world safer than it now is."*

The forecasts have been both accurate as to substance and inaccurate as to time-scale. Many of the wilder predictions have yet to come anywhere near fruition, in part because they have been pre-empted by unforeseen developments. But there seems little doubt that the pace of development is accelerating on all sides, especially as results from the neurosciences and neuroeconomics provide a stringer common foundation for analysing the human and computer aspects of cybernetic systems. While it is not certain that the coming decade will see the wholesale break-out of this trend, its harbingers are all around, from computers that recognise and even experience emotional states to the use of human interactions to extend the range and validity of automated prediction of complex events. As the mutual dependence of human and computer systems and the complexity of the challenges facing each increases, there seems ample reason to anticipate a tipping point in the direction of this trend.

1.3.2 Directly associated technology trends:

Increased deployment of nanotechnology. Currently nanoscale engineering is limited to 'close to market' research and development activities, test-beds and sector specific applications (such as semi-conductors in the microchip industry). This narrow vertical development is likely to become less and less prevalent, as nanotechnology becomes more pervasive and institutionalised firstly in medicine and healthcare applications and the pharmaceutical domain and finally more common engineering areas (e.g. in buildings and materials).

Cognitive computing is a search for computer science-type software/hardware elements that are consistent with known neurobiological facts about the brain and give rise to observed mental processes of perception, memory, language, intelligence, and, eventually, consciousness. Very simply speaking, Cognitive Computing is when computer science meets neuroscience to explain and implement psychology. We have, in the brain and nervous system, an information processing system unrivalled by artificial means. While it trails machines in accuracy and mathematical computation, it wins on adaptability, flexibility, functionality, and parallelism. The ultimate goal is to reverse engineer enough of this system so that the design principles can be applied to building robust and adaptable computer systems. It is related to Artificial Intelligence (AI) and Neural Networks (NN). However, AI and NN technologies take one or more cognitive phenomena exhibited by the brain as a starting point and then try to replicate that capability by inventing algorithms/learning rules. In contrast, CC is about learning how the brain operates, about algorithms, about diligent reverse engineering and testing plausible models.

*Cybernetics, specifically cybernetic organisms (*or. Human/machine hybrid systems) are increasingly being developed at the individual level[18]. But the nature of the technology trend

[16] E.g. Turing (1950).

[17] Cousins (1966) cited in Microsoft (2008).

goes beyond the combination of components to the issue of what it means to be 'human' or 'machine.' Gray (2001) and others have begun to investigate how agency and citizenship will function in cyborg societies, using the full term "cybernetic organism" to describe larger networks of communication and control. For example, cities, networks of roads, networks of software, corporations, markets, governments, and the collection of these things together. A corporation can be considered as an artificial intelligence that makes use of replaceable human components to function. People at all ranks can be considered replaceable agents of their functionally intelligent government institutions, whether such a view is desirable or not.

Immersive virtual environments ranging from social networks to virtual worlds, and entered by a range of devices from the relatively neutral and controllable (keyboards and mice) to the seductively internal (see sec. 1.3.3) represent, in this perspective a convergence between computers (and automated systems) and humans as social organisms. The 'immersive' nature of the experience, and thus the degree to which the boundaries between human and machine or among humans are re-drawn or done away with, is driven both by the comprehensive aspect of the mental engagement involved[19] and (in conjunction with VR tools and other aspects of cybernetic technology) a level of sensory identification with the generated experience that in some cases is stronger than that of 'real life[20]'.Worth noting in this respect is that this represents 'soft' technology (changes in human behaviour and social organisation) enabled by certain applications of (for the most part) known 'hard' technologies (computer networks, software, sensors, etc.).

1.3.3 Closely related technology trends

Decreasing size and increasing capability of embedded sensors The continued reduction in the size of sensors able to detect various parameters (light, heat, sound, radiation, pressure, chemicals etc) and their increasing capability will support and enable human - computer convergence. This will be manifest not only in the direct integration of such sensors and intelligent dust to biological forms, but also in their pervasive application bringing a variety of currently passive objects 'alive' with detection, communication and processing capabilities. Sensors that can detect a broader range of phenomena, ranging from the electro-magnetic spectrum to motion and olfactory capabilities, will have increasing range and more finely tuned abilities. They will be coupled, - perhaps via RFID technology (see below) - to communication technologies that permit the transmission and processing of these data. This will have implications in a wide variety of fields, and gives rise to entirely new control interfaces, such as G-Speak[21] the mouseless control technology ("spatial operating environment") and the use of sensors that detect brain waves and eye and muscular movements (together called bio-potentials[22]) to provide 'thought control' for both healthy and injured persons (including e.g. paralysed or brain-injured people).

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[18] Gray, Mentor, and Figueroa-Sarriera (1995)

[19] Psychologists have noted the hyper-real identification of e.g. video game players with the game world.

[20] Discussed in Ramachandran's 2003 Reith lectures on the BBC. See also http://www.artificialvision.com/etumble.htm

[21] See http://oblong.com/

[22] See e.g. http://www.bjhcim.co.uk/news/2008/n811042.htm or http://technology.timesonline.co.uk/tol/news/tech_and_web/gadgets_and_gaming/article4354041.ece

Cheaper, faster and smaller RFID technology RFID is a very small scale passive and active radio transmitter technology that is powered by radio waves, with ranges up to several metres permitting data to be read / written from a distance. RFID tags are powered via the radio interface therefore do not need an external power source. The trend of the steady advance in the increasing power, decreasing cost and size of this technology will allow its widespread use, outside of specific organisational settings or narrow applications & contexts (e.g. access control or logistics). RFID will conceptually approach and converge upon the biological form, which will open up new avenues for interaction and integration between humans and ICTs. The true benefits from RFID will become realised when combined with other Near Field Communication (NFC) technologies and more generally, communication technologies that are closer and more pervasive to the biological form.

More tools for personal identification and authentication are enabling technologies to this trend-cluster. Many of the elements impinge upon concepts of identity and means to provide for identification will move out of organisational or sector specific settings (e.g. for banking or access control) into the wider sphere. Clearly this technology will be present elsewhere, but it is in this trend-cluster that it will be needed most. Current examples include biometrics, and (by now) somewhat mundane passwords or PINs. Technologies to ensure persistent accountability and governance of personal information may hand back control to the data subject and redress the balance from organisations managing or mismanaging this data. The applicability and usefulness of these tools will become more strained as technological development becomes ever more entwined with biological forms.

1.3.4 **Key uncertainties**

Possible Trend-breaks:

- *Presence of a tipping point*, at which the use of these technologies will change rapidly *from limited, sector or application specific areas* (e.g. medicine or assisted living) *to widespread use* (e.g. in home appliances and ambient intelligent technology embedded into everyday objects). Near term limited use by narrowly focused socio-economic groups, restricted to wealthy highly tech-savvy countries will thus evolve more or less rapidly into broader, more pervasive use, across everyday objects and activities. The uncertainty is whether this will happen as a result of socio-economic factors, the failure (or not) of regulation and/or government leadership programmes or by some other catalyst.
- Government support for *funding of nanoengineering* may spur or degrade the broader implications of this trend, particularly in the developed world.
- *Presence or absence of trust* will be a key uncertainty, as the technological developments in this trend-cluster are closely intertwined with current conceptions of the boundaries of human and biological entities. The majority may be untrusting of technology, because of the uses it has been put to by others (including other societal groups, individuals and even governments and corporations) and the perceived possibility of new risks and vulnerabilities. As with other potentially disruptive or untrusted technologies (e.g. GMOs, animal testing) this could lead to civil unrest and various forms (individual to political) of backlash and ultimately to a distortion or cessation of supportive policy,
- *Social acceptance* (and appropriate use) of the technologies is an uncertainty that is related to the previous uncertainty. This will depend on user and non-user beliefs regarding safety,

reliability and knock-on effects, especially at the individual level (e.g. health concerns, vulnerability to malign or accidental interference, etc.).

Other Socio-economic drivers of and responses to technology trends

These new technologies can remove the involuntary impediments to broad inclusion; however, in the process, they may influence voluntary (predominantly) self-exclusion or the hardening of individual choices regarding these technologies into more profound divisions between pre- and post-modern beings. As the technology trends in this cluster and of the Infrastructure Convergence begin to have their effect, more and more people will be able to benefit from ICTs and initiate or expand participation in a global digital system. This will be made easier by the transparency of access and connectivity and the absence of a requirement for anything resembling the traditional apparatus of computing (e.g. a Personal Computer, keyboard or even a mobile device) – especially for those to whom such interfaces present specific barriers. Ironically, although convergence between ICTs and the physical or cognitive elements of biological form *enable* access to the benefits of ICTs for the large proportion of the world' population[23] who are digital 'have-nots', many of them – together with many digital "haves" –view this convergence as distasteful and wish to retreat. These 'digital hermits[24]' will shun ICTs as altering the very meaning of what it is to be human (or a biological form) or shun ubiquitous interconnection as spelling the end of privacy or the individual. The prevalence and impact of digital refusal will be determined by the welcome, distasteful and unintended effects of law, policy and the behaviour of companies, public administrations and civil society groups (changing levels of trust) and other external shocks that cannot be easily predicted.

There will be *changing forms of criminal activity* as potential targets - holding some appropriable monetary or economic value - change, reflecting where this value is held. This is the case with the mixing of real and virtual worlds where there have been various cases of real life crimes committed in order to obtain virtual wealth. In addition, there may be a degree of displacement or substitution. For example, technologies such as implanted electrodes or transcranial magnetic stimulation offer the prospect of electronic analogues to (or improvements on) drug experiences that can be shared, interactive and delivered or

[23] These divides are the subject of a variety of literatures. Access to and attitudes towards the Internet – and the realisation of benefits from Internet use – are mutually-reinforcing. Moreover, they are social phenomena. Therefore, while it is possible to measure differences in Internet access along regional, educational, class, ethnic, gender, age and other dimensions (see e.g. "Interactive content and convergence" report at http://ec.europa.eu/information_society/eeurope/i2010/docs/studies/interactive_content_ec2006.pdf for geographic divide), it is probably more accurate to see lack of access by any group as a combined effect of lack of expressed desire on the demand side and lack of profitable return to access providers on the supply side. It therefore follows that stimulating one or the other side can trigger a critical mass breakout in levels and types of Internet use. Something similar happened with e.g. electricity or telephony, see Cave (1999).

[24] This term is used as a loose characterisation. The reality is more complex; the pace of adoption is slowed by the reluctance of (among others) those wishing to retreat from pervasive ICT, those wishing to prevent cybernetic convergence, and those merely wishing for a more considered pace of progress. This reluctance therefore presents not a fixed obstacle but a moderating and shaping influence, varying across cultures as well as technology trends.

coordinated over communications networks[25]. Finally, criminal activity aimed at disruption or harm rather than monetary gain (from assault[26] and other crimes of violence to terrorism) may also change form.

Other social drivers might be in *the mixing of real and virtual worlds and social harms that may result* (parallels may be seen with gambling) or in the changing attitudes and acceptance of what may be perceived as meddling in humanity. Clearly, cultural and religious norms will play a role here and have varying levels of importance depending on geographic location. Finally there is a deeper philosophical question as to whether the trends will reinforce social exclusion rather than addressing it. Will an intelligent, rich, powerful and educated minority use these technologies to become even more "intelligent" and educated, leaving the majority excluded? Will the 'enhanced' form an elite ruling a less-converged majority, or a subclass of specialised servants of the majority[27]? Will enhancement serve personal or collective (e.g. economic, military, etc.) interests?

1.3.5 Governance aspects

A number of governance challenges related to this human-computer convergence trend cluster will affect its development, in particular:

- This trend crosses un unusually wide range of regulatory and policy domains;
- These domains are assessed and regulated in profoundly different ways from those usually invoked in relation to ICTs and the Internet – plausible uses of these technologies deliver content in very powerful ways (calling for extensions of current content regulation), affect cognition (potentially touching on the way drugs are regulated), etc.;
- Rapid and potentially disruptive technological development and the possibility of profound and irreversible impact upon human characteristics and development call for a careful balance of *ex ante* and *ex post* regulation;
- The exploitation of this trend can have profound impacts on competition and competitiveness – reaching global markets in time with defensibly unique solutions may require RTD and deployment support;
- The adoption of these technologies rests on cultural attitudes to human-machine convergence and the development of suitable control measures, which must reflect (in

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[25] Because they offer similar (or enhanced) dangers resembling those of drugs as well, it is to be expected that their use may be sanctioned, leading to electronic (and net-enabled) versions of drug trafficking and distribution. See e.g. Nutt *et. al.* (2007).

[26] It may be necessary to redefine some offenses such as assault in order to recognise that attacks via the human-machine interface may have the same immediacy, possibility for permanent harm and lack of individual safeguards that traditionally placed physical attack in a more serious class of crimes than e.g. fraud. See e.g. Montgomery *et. al.* (2006) and Geach and Haralambous (2009).

[27] Note that technological 'haves' need not be elites themselves; it is possible that a technologically enabled minority could undermine elite interests and advocate in favour of the (possibly disadvantaged) majority along lines already clear from e.g. www.mysociety.org or http://www.avaaz.org/. In relation to cybernetic enhancement, this will require either people outside incumbent elites to have access to enhancement or selective uptake within incumbent elites leading to a reawakened societal conscience – as happened in the wake of expanded higher education access in the US civil rights/antiwar movements.

addition to technological, economic and safety considerations) the ethical dimensions of what it means to be human; and

- The universal (non-national) potential of human-machine convergence, the difficulty of identifying or sustaining adequate jurisdiction and the profound (geographic) separation of supply-side controls and returns from demand-side use and impacts mean that both policy issues and effective responses must be defined at a global level; to influence the solution a global coordination and 'enlightened leadership' is required.

One consequence of these challenges is a strong potential for using the precautionary principle to emphasise *ex-ante* regulation to control new services. The advantages are reduced regulatory cost and (potentially) increased consistency across policy domains and technologies. The risks include rapid obsolescence that could impede innovation. More precisely, if *ex ante* regulation is used within the EU but not elsewhere, it may have the effect of slowing innovation (to the extent that EU firms would otherwise have led the way), reducing competitiveness but not materially protecting EU citizens from risky applications (on the assumption that such controls are more effectively enforced on suppliers than on users). Of course, in any case *ex post* sanctions may be applied if harm can be demonstrated. The risks in this case are that some harms may be irreversible, that reputational damage may punish innovators and prevent the deployment of even 'fixed' versions of problematic technologies, and that – because expected sanctions depend on the information available to regulators – the threat of *ex post* punishment may inhibit the collection of potentially damaging information (analogously to the development of drugs and other chemicals).

There is therefore a risk of a sub-optimal combination of *ex-ante* regulation and extensive *ex-post* 'work-arounds' through which governments try to deal with the implications of these trend-clusters on a case-by-case basis. The potential for inefficient and ineffective regulation is magnified by limited understanding as to where innovation in this highly dynamic domain will lead and how the consequences will spill over into other policy areas (e.g. health, privacy, safety, etc.).

The regulatory challenges for this area can be framed in terms of a series of questions:

- Do the issues provide a basis for new regulation or can they be handled by adapting or changing existing regulation?
- Do the issues or solutions involve computer enhancement of human capability or human extension of computers? In the former case, the issues involve mainly safety/privacy, and some economic/consumer protection issues; in the latter case, it may be necessary to expand, alter technical regulation of computer systems to incorporate both human failure and 'emergence.' Even where it is not appropriate to draft *ex ante* controls or place 'liability,' there may nonetheless be a need for control, guidance or mitigation;
- To what extent does ICT regulation need to reflect the precautionary principle? *Ex post* regulation may come too late, but *ex ante* regulation may foreclose potentially useful innovation;
- Does computer enhancement of human (online) decision making force a reconsideration of the status and incorporation into legal regime of cybernetic 'legal persons'?

Beyond regulation, *RTD support* is already an active area of policy intervention with demonstrated impact and is expected to remain as such. This ranges over targeted project-specific support for specific technologies, centre-based attempts to analyse and manage the issues created 'in the round' (in connection with e.g. neuroscience, complexity science and cybernetics) and regional innovation cluster support (e.g. the Bioregio programme). Procurement policy is a likely tool in areas narrowly focused on public service delivery (such as eHealth) and access/identity (eIdentity management). The use of RTD support will be to some extent competitive, compared to e.g. infrastructure development or other, more localised technologies. The leading Information Society nations may publicly support these technology trends *via procurement and deployment initiatives*, creating digital cities full of embedded technology in order to showcase their industrial capacity (current examples include S. Korea and India). Others will be wary of opening what they see as a 'Pandora's Box' which may have unknown yet wild and distasteful implications further down the line.

Ultimately, the choice of policy instruments and levels of intervention will depend jointly on the degree to which perceived stumbling-blocks lie with innovation, acceptance and adoption or the development of suitable control measures, and on cultural attitudes to human-machine convergence. For this reason, here more than in other clusters, the relation between innovation policy and regulatory control as routes to the identification and resolution of societal problems needs to be made explicit.

Given the important *ethical dimensions* of this trend cluster, government intervention (especially in more traditional societies) may become interventionist and at times reactionary *in the face of perceived assaults on what it means to be human*. AI-like technology is already becoming more prevalent in the developed world, with decision support systems and the delegation of tasks to ICTs. The likely slow but steady emergence of deeper interactions between computers and humans will challenge policy-makers, who may look upon direct regulation or withdrawal of RTD and development support as the tools of choice to (be seen to) manage these developments.

Other policy levers include *education,* particularly in the innovative sciences required to take theoretical research into the realm of applied technology and the social sciences needed to understand and cope with acceptance and socioeconomic impacts.

The 'common standard' of the human side of hybrid structures, the ease of technology proliferation (these technologies tend to have low marginal costs once research and development costs have been met) and the global reach of the networks to which such converged entities may connect (which builds adoption demand) mean that *policy issues*, not always solutions, will be *defined at a global level.* Those few countries or regional blocks like the EU where these technologies are already at an advanced stage may take a more or less enlightened lead role. International institutions such as the UN and the OECD will try to take leadership positions in relation to issues that may have implications for human society as a whole and in view of the potential of these technologies to contribute to longstanding (e.g. human development) goals[28].

Degree of flexibility

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[28] This can already be seen with e.g. nanotechnology and genetics research.

The question of whether this trend-cluster will be governed by rule-based or choice-based behaviour will be a major determinant of the location of the trend along the open/closed and same/different dimensions (see discussion in Section 2.1). In the short term, individuals may not have any meaningful choice about participating in environments that continuously collect information for data matching and mapping purposes, and that in turn influence their activities via the 'machine part' of their converged existence[29]. Although in certain circumstances - e.g. assisted living - this choice may be given willingly in order to obtain effective and much needed support, the choice on the part of the end user will be more difficult to realise in public contexts (such as an urban setting with sensors embedded into the built environment) or more generally where complex system interactions make the available options and their likely consequences harder to understand and knowingly accept. This raises two deeper issues – the *meaning and reliability of informed consent*[30] *and the implications of growing reliance on automated systems* (in particular the potential need for a third party auditor of the person-machine relationship). Exercising choice in this context may mean that consumers or end users have to reluctantly become digital hermits.

In this respect, the delegated flexibility and reliance on self-governance embodied in the *end-to-end principle*[31] may need substantial rethinking when the 'ends' of the network are inside users themselves; end-users may not be aware of processes running on 'their' computers[32]; if end-users cannot trust 'their' machines it is inappropriate for the network as a whole to trust them, because doing so no longer equates to trusting users, especially if embedded systems become untrustworthy. More precisely, the end-to-end principle is best viewed as a set of related policy issues rather than an overarching 'principle' without formal or substantive (Treaty, law) expression. Relevant aspects of the principle include:

- The architectural aspect – the original principle as stated by Clark et. al. governing the location of protocol functions, whether 'dumb' (e.g. TCP) or 'intelligent (.g. IP).
- The extension to a basis for preserving openness, robustness and reliability;
- A neutrality aspect aimed at protecting user choice and (as a result) the development of new devices, applications, etc.

From these perspectives, the Internet Governance community is working towards a fundamental reconsideration based on: i) decreasing trustworthiness of 'edge' devices (e.g. as a result of malware, botnets, software and connectivity complexity and ever-wider levels of user understanding and motivation); ii) simultaneous emergence of technical capabilities for providing advanced monitoring and control functionality within the system; and iii) increasing potential for failure or congestion in the network itself. At the same time, it is widely accepted that some aspects must be maintained or even strengthened, esp. 'open systems' provisions for hardware, protocols (e.g. the EU ONP Directive), software APIs

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[29] In this connection, Trusted Computing can be seen as a related technology trend.

[30] Indeed, a too-ably supported decision may not be a choice at all – this has been raised in e.g. discussions of the economic impact of location-sensitive information.

[31] See footnote 4

[32] Clark and Blumenthal (2007).

(open standards, open source), etc. Note that these characteristics also dominate the projected impacts of the other trends.

Finally, openness as regards hardware connection and interoperability and content transmission carries an implication of technological and service neutrality that overlaps the 'net neutrality' debate.

Responsibility and accountability

Interesting policy challenges arise from the interaction between the closed world of proprietary nanoscale manufacturing and the more farfetched ideas about biological alteration, namely whether regulatory models based around value from the exploitation of *Intellectual Property Rights (IPR) can be extended to biological forms and to hybrid processes.* Other difficult questions arise with regard to *governance and ownership of the information and data collected* (or collectable) from the use of these technologies (DNA data, locational information, biometric data and tagged records, etc.)[33]? Additionally, the organisations that help to carry this information and associate it with other data must have some provision for accountability. The response to any such assignment of responsibility may undermine the original benefits - for instance if individuals choose to go 'off the grid' for socially (or even individually) insufficient reasons, reducing the 'network benefits' of a densely interconnected society. Another backlash is the crowding out of discretionary, effortful individual responsibility by reliance on automated systems whose superior performance may not be scalable. Finally, the same technologies that create the potential to extend surveillance (even for the benefit of those under surveillance) may be used to defeat such systems by spoofing, masking or signal jamming – the harm done by this is proportional to reliance on such systems.

1.4 Trend 3: Utility Computing

1.4.1 Trend description

The key characteristic of this trend is that computing power and digital storage no longer attract user attention; they are simply available as needed. In its most basic sense, this cluster entails the packaging of computing resources, such as computation and storage, as a (metered) service similar to a traditional public utility. However, as noted below the evolution of internet-based computer access need not share the control or billing characteristics of other network utilities, in which the economic 'pinch point' is derived from either the costs of generation and/or distribution – the sharing of spare computing resources over unsaturated networks may have no scarcity or costs of tangible resources, but may be more constrained by the need to provide *intangible* public goods such as ubiquity, reliability, security, etc. without a *tangible* point of control or regulatory purchase. As with electricity, such characteristics must be present before it can be considered as a utility resource.

When combined with technologies from the Infrastructure Convergence trend cluster, utility computing as a concept can spur or enable huge expansion in the power and scope of

[33] In this regard, note that issues concerning the commercial or economic uses of such data are shadowed by issues relating to the forensic or legal uses of the same records.

computing. Three specific (but overlapping) technology clusters should be highlighted; grid computing, cloud computing and "Everything as a service".

From the perspective of uptake and utilisation, the essential feature of this technology trend cluster is that most users merely rent or gain access to– but do not own - the infrastructure and connected equipment. They thus avoid capital expenditure, consuming (and paying for) only the services provided by computing resources. Most current offerings use either the utility computing model (analogous to traditional utilities like electricity) or billing on a subscription basis. Sharing "perishable and intangible" computing power leads to higher capacity utilisation, which can reduce costs significantly while increasing the speed of application development[34]. A further technical impact is that available computer capacity rises dramatically – because peak demands either do not coincide or can be met jointly, cloud models make supercomputer performance levels (currently 10^5 times high-end desktop performance) available for (suitably-structured) business, scientific and entertainment applications[35], producing quantitative and ultimately qualitative improvements in the productivity of ICTs in these areas. A further potential consequence is that users are insulated from technological obsolescence and the fear of either stranded investment (investing in an obsolete or unsuccessful technology) or of being 'left behind' by the next application, etc. Market participants' rational responses to these risks lead markets with network externalities to adopt new technologies too readily or too slowly compared to the efficient pace of innovation[36].

1.4.2 Directly associated technology trends:

Increasing digital storage capability and decreasing cost per byte current technical advances such as PMR (Perpendicular Magnetic Recording) holographic disk technology, array based memory illustrate this trend of the ever decreasing cost of storage. In the short term it is possible that storage will become so ubiquitous as to be free or at least given away alongside or as part of other bundled products and services. This is already the case with cloud email providers such as Google where customers pay in other ways (e.g. via clicking on adverts). The ubiquity of this storage is also, in the short term at least, dependent upon some form of connectivity (preferably via high speed always on means) but developments in WORM (Write Once, Read Many) media may continue to spill over into re-writable media (as was seen with DVD-RW technology).

Faster computation is part of Utility Computing, and is concerned with the computational speed of processors. Moore's law has been the dominant model of determining the increase in processor speed each year, but the constraints of physics will eventually mean that this will no longer be valid. Quantum computing which promises exponential gains holds the ability to sidestep this restriction and restart the upward curve of processor speed at a steeper curve. Quantum computing takes advantage of the principles of quantum physics to deliver

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[34] In addition to making greater use of existing computing cycles, a shared service architecture provides better feedback on which capacities are most heavily used/valued, allowing innovation to track evolving patterns of use.

[35] Carey (2008)

[36] Katz and Shapiro (1985) were the first to draw attention to this potential source of coordination failure. Excess volatility will result if risks of being left behind or losing an irreversible first-mover advantage dominate; excess inertia will result if participants are more concerned about choosing the 'wrong' new technology.

increases in processor capability of orders of magnitude beyond what current nanotech etching processes permit. However quantum computers have yet to go beyond the research lab or test-beds. In the future, other more exotic forms of computation may even replace quantum computing.

Evolving computer architectures Another related set of technological developments is that of the evolving nature of computers themselves. Current examples include virtualisation[37] and System on Chip (SoC). Virtualisation is the practice of running many instances of a computer on a single physical infrastructure. System on Chip is an architectural computing model that includes all the separate pieces[38] of a computing device on a single microchip or semi-conductor wafer. This is very prevalent in the realm of mobile and embedded computing. SoC is particularly relevant, since it facilitates the endpoint infrastructure that connects to the Infrastructure Convergence.

Grid computing involves the application of several computers to a single problem at the same time. The grid concept is also used to provide homogeneous 'basic' computational and data resource access within specific organisational settings as well, or to provide access to specialised applications to diverse users[39]. It divides parts of a program among as up to many thousands of computers, like distributed and large-scale cluster computing or network-distributed parallel processing. It can be confined to a single company's computer network or a large public collaboration across many companies or networks. Compared to cluster computing, grids tend to be loosely coupled, heterogeneous, geographically dispersed and composed from general purpose software and middleware.

Cloud computing - while a grid is more 'open' than a computer cluster, it nonetheless has relatively high levels of structure, control and identification[40] - thus the overall function of the grid is relatively well-understood and the computational resource is more a directed input than a 'generic' service. The purest expression of computing-as-service currently is *cloud computing*, defined[41] as a paradigm in which information is permanently stored in servers on the Internet and cached temporarily on clients' hardware. The essence of this development from the perspective of this study is that cloud computing holds the promise of allowing users access to technology-enabled services from the Internet without knowledge of, expertise with, or control over the technology infrastructure that supports them – or in many cases the services themselves. It includes the 'software as a service' concept behind e.g. Google Apps, which provides common business applications online that are accessed from a web browser, while the software and data are stored on the servers, (some aspects of) 'Web

[37] As used here, the term refers to the technical separation and (re)bundling of a wide range of ICT resources, including: *platforms* (the separation of operating systems from their underlying hardware platforms), *resources* (separate, simplified and 'insulating' interfaces around storage, memory, network addressing, communications channels, etc.), *computers* (the assembly of large 'virtual computers' - clustering, grid or cloud computing) , *applications* (running applications on different hardware, operating systems, etc.) and *interfaces* (managing desktops and other interfaces remotely).

[38] e.g. system, data and application memory, processor, visual and sound interface, haptic interfaces

[39] e.g. Server and Rendering Farms that support application- and storage-intensive computer game development.

[40] Specific tasks are performed in specific places with only minimal and highly-parallel redundancy.

[41] IEEE (2008)

2.0" and other developments in which the Internet becomes the basic platform for meeting users' computing needs. It is also not the same as utility computing, though cloud access is currently provided and billed as a utility. Indeed, many cloud applications have no centralised control, monitoring, billing or quality management facilities whatsoever[42].

Everything as a service[43] is a special case of cloud computing involving access to re-usable, fine-grained resources made available over a network. The key characteristics defining a 'service' are: low barriers to entry (esp. to small businesses or end-users); minimal capital expenditure requirements (major items are owned by providers); scalability (though this is most important in identifying or characterising *mass services*); 'multitenancy' (allowing costs to be shared among many users); and device, platform and location independence.

1.4.3 Closely related technology trends:

More internet capacity increasing capacity and evolving functionality of the Internet as a network are closely associated with this trend as enablers of access to shared storage and computing resources. Network neutrality policy, which may alter the terms on which computing/service providers and users may interact, will obviously play a role in shaping the evolution of this tech trend.

Open source software –collective approaches to Utility Computing service depend on the ubiquity of software performance – applications must be available throughout the grid or cloud in the same or equivalent form, must interoperate independently of platforms and locations, and must not create barriers to uptake, since low or patchy uptake jeopardises the underlying economic model. The first two characteristics can be provided by open-source or dominant proprietary software, but the third is increasingly met only by open source models (e.g. in Linux domination of server software, open-source libraries of grid routines, etc.).

1.4.4 Key uncertainties

Trend breaks:

- *Positive feedbacks can lead to discontinuities* (sudden take-off) through which small changes in initial conditions can trigger big changes in outcome. On the user side, demand for content (especially high-bandwidth content) will drive the growth of network *storage* (especially local peering to conserve backbone capacity and improve performance and capacity utilisation). On the other hand, the growth of user-generated and shared interactive content (Web 2.0 development) will increase the demand for network *computing*. Both of these are driven by two-way positive feedback loops: high-definition content is linked to shared storage capacity, interactive content creation is linked to network service computing; interactive immersive environments are linked to both storage and computation. The outcomes may vary: the relative early success of scripted (storage-intensive) versus fully interactive (computation-intensive) virtual environments can trigger storage-as-a-service or computation-as-a-service. In a storage-based scenario, the (asymmetric) two-sided complementarity between content creators and content users will

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[42] E.g. peer-to-peer networking applications like BitTorrent, eMule, Skype, etc.

[43] See e.g. "Everything as a service" *Information Age* at: http://www.information-age.com/articles/292231/everything-as-a-service.thtml

reinforce subscription-based models and will enhance the 'platform power[44]' of hosts, ISPs and other intermediaries and a regulatory engagement based on competition rules. By contrast the more symmetric relations involved in computation-rich evolutionary scenarios will lead to a more 'infrastructural' role for service providers, a free or metered use business model and a regulatory stance more reflective of conventional public utility regulation.

- Another source of this sensitive dependence on initial conditions is the inherent *complexity[45] of an Information Society based on utility ICT services* compared to today's more highly structured Internet interactions. In this world, emergence and synchronisation are highly likely and control in any sense is more difficult. Thus, such a system can not only give rise to quite distinct (very different, but sharply defined) futures (as a result of the positive feedbacks mentioned above) but is inherently harder to predict or manage. This fundamental uncertainty is deepened by two other consequences of utility computing.

    1. *Topology of connections becomes endogenous* – the most likely development of this trend will lead individuals to form 'virtual clusters' within the network based on common need for access to similar data, requirements for similar computational services and mutual engagement in shared content creation and other interactive (rather than parallel) computation-intensive transactions[46]. At a gross level, falling prices, and the migration of most necessary capabilities and services onto the Internet platform will lead to a much greater level of effective penetration of the Internet itself[47]. Therefore, a wealth of 'small world[48]' groups could form, persisting in divergent courses of development. On the other hand, the increasing diversity of individuals' 'network-homed' activities may lead to these clusters becoming increasingly and densely interconnected in other ways.

    2. *Behaviour of individuals* – the services they use and the way these are combined for the purposes of productive activity, consumption and social interaction – *are themselves likely to change* as the range of services available on-line increases. This will change the socioeconomics impact of the underlying technology and the way policy and societal issues are dealt with (how and by whom). From the scenario perspective, an important implication of the bottom up dynamics and complexity of this technology trend is the way the uncertainty surrounding the ultimate socioeconomic impacts is 'endogenised' by the ability of a wide range of stakeholders to take important actions in response to changing circumstances. Therefore, the 'shape' of the scenario is can be understood and ascertained more by analysis of social, political and economic behaviour than by outside factors.

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[44] e.g. Rochet (2006)

[45] In the technical sense: a system comprised of semi-autonomous interconnected and interacting subsystems.

[46] In a conventional distributed computing model the pattern of connections is pre-structured and hierarchical. In a pure cloud environment connections are transitory and entirely unstructured.

[47] Under all of these trends, more and more people will be 'on the net' – the distinguishing feature here is not mere connection but the range and importance of ways this connection or access is used.

[48] Watts (2002)

- *Proliferation of open or proprietary standards* can be another key (but largely generic) uncertainty, particularly relevant to storage and application design. It relates in particular, to the question of whether the current apparent tendency towards open and democratic 'cloud' will be reversed in favour of a more controllable or commercially rewarding dominant technology, or will be cast into disarray by major security, privacy and reliability challenges as complexity increases and control weakens.
- *Extent and nature of social acceptance* is the key uncertainty for the mass appeal and use of grid and cloud computing. It seems fairly certain that grid computing will break out of its current scientific and technical niche, and come to the attention of the masses through radical or newsworthy scientific discoveries, only possible via the donation of spare processor cycles to data mining efforts. Similarly, current examples of Service Orientated Architectures and cloud computing (currently exemplified by Google Apps) will also serve to articulate the message that the computer may not need to be an appliance, but rather could be somewhere in 'the cloud' and permanently available online.
- The need for *large data centres brings another set of uncertain dependencies*, including *environmental* (given the energy requirements of data centres), *security* (they will be a particularly attractive target) *and international policy* (given the current tendency for them to be localised in particular domains and the infrastructures of particular corporations). Growing environmental awareness and security concerns do carry the risk of a slowdown in the deployment of needed infrastructures and thus the availability and 'reach' of service. It may be that growing demand for ICT data-centres contributes to research into green technology and collective security issues so that previously divergent trends may become mutually supportive or dependent.

Other socio-economic drivers of and responses to technology trends

The easy availability of storage will have consequences for production and control of content, some of which may be considered criminal in nature in the context of current regulation. Society will also react to the permanence of storage and recording of such vast quantities of data about their everyday habits. This may result in acceptance (as in the case with CCTV in the UK) or more anarchic attempts at resistance. Concerns over privacy and the 'digital wake' left behind by Internet users may increase and privacy pragmatists may become increasingly numerous, polemical and active in their refusal.

Unlimited storage will have implications for education and the creation of new knowledge but it is impossible to tell what these implications will be. Will the easy availability of information relating to research mean that more and better quality research is done, or conversely lead to a culture of tacit approval for plagiarism[49]? Finally, with the extreme

[49] This depends on human (or augmented) capabilities for data processing and comprehension. To produce better science, people will need to learn to be better at data sifting and new jobs/roles (data scientist) may emerge, On the other hand, there will always be too much information for available resources. The resulting difficulty in identifying and digesting all relevant information, combined with the (transitional?) tendency to emphasise the most recent information may prolong or intensify duplication, contradiction and/or gaps in knowledge. Two human factors that reinforce this unintended consequence of increased technical (but not necessarily cognitive) knowledge handling capacity are the 'herding dynamics' that can cause excessive clustering (too-rapid and too-

dependence upon storage in 'the cloud', the dependency of this resource will be of paramount concern, as will availability – there can be no 'time-out errors' in era of utility computing.

1.4.5 Governance aspects

Key policy issues affecting this trend cluster are likely to be:

- The need to safeguard openness of the 'cloud' and guarding against technological foreclosure, including interoperability and open standards
- Ensure availability of new infrastructures and the incentives to invest
- Consumer and citizen rights in diffused processing, storage and transmission of their data; possibly including a right to opt out, and affordability of protection[50].
- Finding the effective balance between ex ante and ex post policy levers and dealing with inter-jurisdictional and supranational coordination.

This trend will also be affected by *non-regulatory policies such as RTD investment and workforce and labour education to create the knowledge* and intellectual basis for innovations in this area. Current examples can be seen with the way that local investment, favourable regulatory regimes and direct economic stimuli have helped to develop copycat 'Silicon Valleys' all over the world (from Taiwan to Wales) and software clusters such as the Bristol computer games cluster, and more general 'code-cutting' agglomerations in e.g. Bangalore or the Maghreb.

Government policy is likely to focus upon these forms of support, which offer at least the short-term promise of embedded returns. In the longer run, however, the globalised, flexible and rapidly-changing nature of the services will probably erode the profits from utility computer provision. As with other utilities, the political balance of policy objectives may move from protecting the rest of the economy from the bottleneck power of essential utility providers to protecting the provision (if not the providers) of these essential services. The evolution may be sharper and faster for utility computing than for, say, electricity since computing is more heterogeneous, less characterised by natural monopoly and far easier to supply remotely.

Flexibility

Current legal contexts for many technology trends that facilitate increased storage and network-enabled computing *are rule-based*, due to the supposed disruptive nature of these innovations (a good example was an effort by US lawmakers to put an upper limit on the storage capacity of Personal Video Recorders). The application of legislative rules like the DMCA to broader areas like Internet streaming seems to indicate a continuation of this context. It looks unlikely that increases in processor speed or radical improvements to storage technology will sidestep these legal barriers. In the technological domain, these

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rigid paradigm formation) and incentive mechanisms that over-promote apparent originality. See e.g. http://www.senseaboutscience.org.uk/pdf/PeerReview.pdf).

[50] Expensive in terms of investment cost, necessary learning, lost interconnectivity, uninsurable risk and liability.

trends will be characterised *by rules and standards*, whether internationally agreed (e.g. IEC/ISO) or *de facto* imposed (e.g. VHS) standards.

Locus of responsibility

Responsibility and accountability in this domain will fall between national regulators and industrial participants. There will be limited opportunity for civil society involvement with co- or self-regulatory bodies due to the strong industrial involvement in the technological aspects of this domain. However, the global nature of key players (e.g. Google) may evoke a grassroots response that triggers international cooperation or supranational regulation.

1.5 Trend 4: The Intelligent Web

1.5.1 Trend description

The Intelligent Web trend-cluster can be considered as the construct of an interface to the Internet of Things, permitting the end user (whether that be an organisation or individual consumer or user) to extract social or economic value based on the underlying technologies provided by the other tech trend-clusters. This trend cluster is thus about technological trends that directly permit the interconnection of users and organisations *and* value; whether that be social, economic or societal value.

From a technical perspective, this trend is similar to "Web 3.0[51]" – by analogy with file permissions, the first (1.0) Internet was 'read only' (primarily concerned with access to content); the current version (2.0) is 'read-write' (still content-based, but with large-scale participation in content creation); and 3.0 is 'read-write-execute' (including the ability to use the still exponential growth of computer power to develop websites equipped with resources to run user-contributed code. This "executable web" can morph online applications into Omni Functional Platforms[52] that deliver a single interface rather than multiple nodes of functionality. Thus, it combines elements[53] of:

1. Infrastructure Convergence
   - Ubiquitous connectivity, broadband adoption, mobile access and mobile devices;
   - A shift from today's network of separately siloed applications and content repositories to a more seamless and interoperable whole;
2. Computing as Utility
   - Network computing, everything-as-service business models, Web services interoperability, distributed computing, grid computing and cloud computing;
   - Open technologies, APIs, protocols, and data formats together with open-source software platforms and open data (e.g. Creative Commons, Open Data License);

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[51] The term was coined by John Markoff of the New York Times in 2006. For more discussion, see http://www.britannica.com/blogs/2007/07/web-30-the-dreamer-of-the-vine/

[52] Wainewright (2005).

[53] Bulleted categories relating to each technology trend adapted from Spivack (2006).

- Distributed databases (e.g. "World Wide Database" enabled by Semantic Web technologies)

3. Human-computer Convergence
   - Open identity (e.g. OpenID), open reputation, roaming portable identity and personal data;
   - Intelligent web and Semantic Web[54] technologies such as RDF, OWL, SWRL, SPARQL, GRDDL, semantic application platforms, and statement-based data stores;
   - Intelligent applications, natural language processing, machine learning, machine reasoning and autonomous agents.

Clearly, though the component aspects can be roughly mapped to the other clusters, there are some aspects of this trend cluster that can be considered independently – in particular, the opening up and sharing of execution power and the semantic web aspects. Perhaps the simplest way to visualise the latter aspect is to consider the layering of the Internet as a human construction: institutions, human beings and meaning (semantics). Much of what has been said about the preceding three trends concerns structure and function in the layer of institutions and organisations, and their interactions, structure, and functionality within the layer of human beings. The final technology trend adds to this a layer of (semantic and syntactic) *meaning*.

Each layer can be considered as a network in its own right; institutional and individual nodes linked by shared or complementary functions, transactions, responsibilities, data and other flows, etc. These links differ in strength, direction, duration and resilience, and define the proximity or distance between the nodes. Technological and policy developments can change the pattern of links, bringing nodes closer together or further apart. Moreover, changes in one layer affect the other; services offered by an institution (e.g. a service provider) connect or separate people; links among different groups of people (e.g. in different countries) bring the institutions (e.g. governments) with which they are concerned into harmonious or competitive contact, etc. The recognition of the semantic layer simply continues this metaphor; innovation can be seen as the formation of new links among ideas, applications etc. Moreover, services offered by institutions (e.g. hosts of virtual worlds) not only bring people into new forms of contact; they also catalyse innovation through shared or competitive exchange and exploitation of ideas. The key conceptual observation is that this whole layered system is subject to evolution; technologies change the strength and other characteristics of links and thus influence evolutionary forces. The transformation results in the emergence of new forms as the 'units of evolution' e.g.:

1. Institutional groupings of self- and co-regulation, industries and market sectors;
2. Personal communities of interest (e.g. MMORPG players) and cybernetic organisms; and
3. Semantic groupings - new types of content, hybrid concepts such as Web X.0, families of standards, patent clusters, etc.

[54] This is an evolving extension of the World Wide Web to incorporate semantics of information and services in a way that allows the web to 'understand' and satisfy the requests of people and machines to use the web content. The concept originated with Berners-Lee, Hendler, and Lassila (2001).

Applying the network evolution perspective to this trend cluster helps us to analyse the likely future evolution of specific developments originating in other clusters. For instance, the roots of virtual worlds may lie in the supporting infrastructures, shared storage and computational facilities, human-like processing and novel interfaces of the three trends described above, which 'explains' their current instantiation as persistent online multi-media environments such as World of Warcraft or SecondLife. However, as human and computer interaction deepens (in the virtual as well as real worlds) the boundaries of what it means to be part of a human or virtual web will shift, blur or even disappear – this essentially semantic shift replaces the former 'end-to-end principle' discussion of whether 'intelligence' should lie at the 'edges' or the centre of the network with a more nuanced discussion of the meaning of intelligence in a networked society of shared roles and identities.

The important near-term implications of the technologies in this trend derive from their proximate impacts and 'generative capability[55]' (what they enable). People and networks and organisations can connect, collectively create and share, using the technologies in this trend-cluster as an interface built on top of and to other technology trends[56]. Examples include the Open Source movement whose 'many eyes' model of software development would simply not be feasible without early examples of these tools such as Usenet. Other examples include grassroots movements for which technologies have served as a catalyst for group formation, discourse, the raising of awareness and the accumulation and exercise of 'efficacious voice.[57]' Examples are the anti-globalisation movement, flash- and 'happy-slapping' mobs, the rise of the citizen journalist reporting directly from events (creating the news) via ubiquitous camera or video equipped mobile phones and the 'Obamasphere' in the recent US Presidential election.

Another facet of this trend cluster that will enable Human – Computer Convergence is the way that information and applications can be localised and made pertinent to the context of the reader / visitor / user. User friendly and rapidly developed context aware applications mash geographic, location, behavioural and other data making them accessible to the consumer or citizen to facilitate the seamless information environment. Examples include a web-application running on a mobile platform that alerts users to the presence of a favourite restaurant or others with likeminded preferences.

These technologies will give rise to both new business models and requirements, as demand for wisdom and intelligence to be derived from this information will increase. Companies will identify economic value in being able to help people and organisations make sense of their environments and contexts though location aware tools. The provision of these tools will not just be restricted to companies however. Citizen creators will be able to rapidly develop and share such tools. Similarly, social networks will continue to grow and evolve and bottom-up organic collaborations which use this technology will become more important to help create societal goods and provide economic opportunity.

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[55] Zittrain *op. cit.*

[56] e.g. www.avaaz.org

[57] Coleman *et al* (2008)

1.5.2 Directly relevant technology trends

Convergence of applications concerns the transparency of what can be done with different devices at the endpoints of the infrastructure. This goes hand in hand with Infrastructure Convergence, but in this trend, what matters is what can be done with the device - whether it be a mobile phone, television or radio set, multi-media player, personal computer or any kind of electronic device which facilitates human interaction. Examples of the key technologies here are streaming and compression protocols and technologies that permit high definition multi-media to be transmitted to a wide variety of devices (as determined in the Infrastructure Convergence trend-cluster)

More, easier and better creating & sharing tools Other relevant technology trends include the increasing proliferation of tools that permit the sharing of information, intelligence and user created content. Current examples include video sharing tools (YouTube) web sites that permit the sharing of personal information (MySpace or Facebook) or expert content (Wikipedia) or multimedia tools like pod-casting or vod-casting. These tools make use of a wide variety of web-technology, most notably open APIs and Service Orientated Architectures but also 4^{th} generation coding and, semantic markup languages (e.g. XML). 'Drag and drop' software engineering technology will continue to simplify the development of applications. Current examples include the APIs built into Google's toolset and user created applications on MySpace or Facebook.

Web 3.0 tools As noted above, executable web technologies, network computing tools, distributed "Data Web" tools[58] including digital archiving and methods by which (initially structured) data records can be published to the Web in reusable and remotely queryable formats. They also include cognitive computing (see Sec. 1.2.1.), predictive markets[59] and other technologies that e.g. predict hit songs from mining information on college music Web sites. There is a related debate[60] as to whether the intelligence of the Intelligent Web will by a consequence of the use of intelligent systems, or a more organic emergent consequence of systems of intelligent people, e.g. via collaborative filtering services (del.icio.us, Flickr and Digg) that extract patterns (and ultimately meaning) from how people interact with the existing Web.

1.5.3 Closely related technology trends

Localisation of applications Location based services will become ever more popular and integrated with other sources of information and data. GPS and satellite location technology will continue to evolve and be supplemented by technological advances in wireless communications technology (current examples include the way in which base station data with an accuracy of 1.5km is being integrated with GPS geo-location data). These applications will also evolve in their ubiquity. For example the use of location based services is currently focused on mobile devices but this the enabling effect of Infrastructure Convergence will make the use of these services more transparent across a whole range of platforms (including in embedded form).

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[58] Soumokil (2008)

[59] Surowiecki (2004).

[60] Markoff (2006).

Beyond these lie other services based in non-spatial concepts of 'location' including advanced (neural net, fuzzy) search tools, profiling, etc.

Decreasing size and increasing capability of sensors this trend is related in the respect of the linkages between sensors embedded into objects of all kinds, and the tools and capabilities that are being developed to make sense of the information they provide. Furthermore, these tools will become ever more accessible to the everyday consumer.

1.5.4 **Key uncertainties**

Trend breaks:

- *Ability of regulation and other policy aspects to engage the right stakeholders in the new participatory domain* enabled by the Intelligent Web. If this engagement fails, participation in the Intelligent Web may be chilled, resulting in its sub-optimal use or even corruption away from societal objectives.
- *Policy response to the ease with which data from different sources can be mashed, assimilated and bolted together* in new ways, challenging underlying concepts of data/information ownership, control and responsibility. The 'recombinant' uses (initially of data and content, but ultimately of processing, transaction and other functions) will not only challenge large swathes of existing law and regulation, but may well evoke strong rebound effects.
- *Societal reaction* will thus be difficult to judge – particularly when combined with the limitless capabilities of computing and storage in 'the cloud' as described by the Utility Computing trend-cluster and the potential (already seen in relation to peer-to-peer content sharing) of people to disregard rules that are difficult to enforce or whose purpose has been rendered obsolete by technology – and ultimately to opt out of collective governance of collective problems.
- *Consequences of facilitating the networking of a far greater range of people and organisations*. Traditional assumptions about shared values and the availability of effective recourse for problems may be violated – in fact or in expectation – which can greatly reduce levels of trust and expose the vulnerable to potential harm. On the other hand, this same opening of networked contact (and the transition from contracted to networked relationships) may bring people into new forms of contact, allowing them to realise new possibilities and to discard obsolete rules, associations, etc. Both of these possibilities can already be seen in the initial steps in the direction of the Intelligent Web[61] (). This may have further implications beyond the Internet domain – for example the way governments (elected or other) deal with citizens, the level and kind of individual and community participation

[61] These steps include e.g. Web 2.0 and the contributions made by the Infrastructure Convergence, Utility Computing and Human-computer Convergence trends. The changing dynamics of interaction involve, for example, engaging 'clouds' of part-time consultants to discuss, debate and solve problems of specific or general interest, thereby replacing experts employed on a permanent and exclusive basis, mobilising dissemination of ideas and harnessing competition to the identification of solutions. Examples of the new forms of interaction include e-lancers *(*www.elance.com), crowdsourcing (see http://crowdsourcing.typepad.com/) and collaborative innovation in immersive virtual environments (see Kukimoto *et. al.* 2008).

and the way companies relate to and inform customers who may be more knowledgeable about products and services than the companies themselves.

- Ultimately, the societal implications and uncertainties of the use of this technology may *undermine or confound the primacy of the nation-stat*e as the preeminent international entity. This process might be accelerated by the proliferation of creating and sharing tools that are easier to use and link to more data via the Intelligent Web. Individuals and organisations using such tools could grow or evolve into other layers of international relationships, especially if the political catalyst function of the technologies (see Sec. 1.4.1) is fully exploited.

Other socio-economic drivers of and responses to technology trends

The prevalence and ease of use of these creative tools *may serve innovation* well, as it may bring to light talent that may not have previously been acknowledged or discovered. Similarly it may cause an information *overload of mediocrity* that requires the intervention of self and co-regulatory filtering and rating intermediaries.

The incentives for creativity may become less concerned with seeing economic reward given the ease with which content can be mixed up and rehashed. As technologies in this trend cluster and that of unlimited storage begin to take effect, content providers may have *difficulty in extracting economic value from their creations*.

1.5.5 **Governance aspects**

The governance effects on this trend can be characterised largely by the unpredictable nature and thus difficulty to choose the right instruments:

- The policy levers most often identified in this space are initially *likely to be primarily ex-post*, given the chaotic, often bottom-up and hard to predict nature of these developments their impacts.
- Standard setting is expected to be an important complementary ex ante intervention (for example in the agreement of languages and interpretations of markup standards)
- There may be individual examples of enlightened regulation (for example with the European Pan European Game Information) in specific sectors but it will be difficult to galvanise any policy response at a general level.
- Another important enabling action by public sector actors is the provision of public sector information; which can impact innovation and increase overall levels of knowledge.

Regulators in general may find themselves outpaced by the creation of these tools and also the uses (both good and bad) to which they can be put.

Flexibility

The trends in this cluster will likely continue to be *highly flexible and determined by individual choice.* Consumer/citizen-creators and civil society will have a broad range of tools at their disposal and will want to port or migrate data, content, applications and processes from one to another (e.g. porting a profile from Facebook to MySpace, exporting (open-source) content from Second Life to other virtual worlds). There will be a landscape of tools that do one thing well initially, but that gradually encompass other functionalities. These will jostle for position and dominance and the *opportunity for disruptive innovation* in this domain will increase. Targeted niche applications excelling at one function will be able to capture market share from bigger incumbents who have tried to broaden functionality away from their core offering.

Responsibility and accountability

Individuals, civil society and regulators at the 'ends' of the Internet are likely to be the main human and institutional loci of responsibility in regard to this technology trend. Regulators *and policy-makers will have difficulty in adjusting* to this, since it will be easier for them to target their regulation at industry and commercial organisations engineering and developing the tools. In addition, the growing capability of the Web itself (considered collectively as "the wisdom of crowds") *may* lead to effective delegation of much of governance to automated systems or (Internet-supported) collective (e.g. market-like) societal mechanisms. At the very least, *regulatory decisions will increasingly rely on the monitoring output of Web 3.0 tools* (see above) to inform their decisions, giving the Internet itself a role analogous to the Oracle at Delphi.

1.6 Summary

This chapter discussed the tech trends, and the supporting technologies and issues that may impact the development of the trend, including uncertainties and governance structures and interventions. To allow an assessment of the possible societal and economic impacts of these trends the next chapter will discuss three future scenarios. These are built following the identification of three mayor dimensions of uncertainty, which differentiate between possible future worlds. These scenarios are then applied to the International Futures model to help gauge the socio-economic impacts, related to the tech trends and influences or driven by the scenario dimensions.

CHAPTER 2 Projecting the future: Scenarios for tech trend development and impact assessment

To allow an assessment of the future socio-economic impact of the Internet of X requires the development of scenarios to describe the future in which these impacts may materialise. Thus this chapter describes three different futures driven by uncertainties about technological development governance models and market development. First we discuss these dimensions - governance models and market development, and then we provide a brief description of the scenarios that ensue. In the following chapter the scenarios will be applied to generate an assessment of possible impacts.

2.1 Developing dimensions for assessing trend trajectories

The complexity of the tech trend clusters makes it hard to predict detailed changes. To clarify impacts, it is useful to organise the clusters along a small number of dimensions, which can then be used to map the scenarios. Here, we describe the dimensions to enable readers to form their own views as to their completeness, accuracy and scenario relevance. The key dimensions, which were chosen on the basis of a review of analogous scenario dimensions from the literature and validated through key informant interviews, are depicted in Figure 2. The discussion that follows addresses each dimension in turn, adding a physical analogy where the metaphor of the Internet as a navigable space seems relevant.

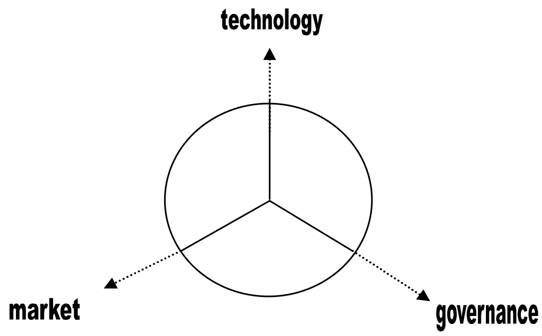

Figure 2: relevant scenario dimensions

The dimensions aligning technology clusters are concerned with *results* - the degree to which they include or exclude technologies, participants and other parts of the Internet of X (the open-closed dimension) and the extent of diversity along different ‘paths’ through the

Internet of X'. The trends will develop along these dimensions in response to framework conditions of technology development, including socioeconomic relationships and policy. By contrast, the dimensions used to characterise scenarios within which socioeconomic impacts unfold are more concerned with *process and governance* – whether the lead is taken by institutions representing collective or individual interests (the public-private dimension) and whether preferences are collected, compared and used to shape decisions in a decentralised or coordinated fashion (the competitive – cooperative/collusive dimension). A detailed description of the selection, logic and mapping of scenario dimensions is given in Appendix B:

2.1.1 **Technological Dimension: Open vs. Closed**

Open technologies or applications facilitate entry, exit and search by technology users and other Internet stakeholders. In deployment, they may lead to a common approach or customised differentiation. Both (one-size-fits-all and diversity) are possible, even essential to efficient outcomes – for instance, the need for interoperability militates against multiple protocols for signal transmission (hence standardisation on TCP/IP) but we would expect a range of applications on top of this, to accommodate differentiated needs without excessive bloat and complexity.[62]. An example of the 'common' outcome associated with an open regime is a common and freely available open standard or technology that serves as an infrastructure; people use it for different purposes, but it is 'customised' at a lower layer (e.g. TCP/IP is open and common, but used to enable http, VOIP, etc.). This openness makes it highly 'generative' – it allows (anyone can monkey around) and forces (by its 'plain vanilla character') bottom-up innovation – but mostly by and for the technical elites and those who have something to sell or provide to the masses. The physical metaphor is a *highway* on which people can go different speeds in a range of vehicles depending on their income, needs and preferences, but all follow the same route regardless of destination. By contrast, a differentiated technology associated with openness might be one that can be highly personalised or differentiated *by its users*, who are encouraged to interact at design level with the technology itself more than the way they use it. This is related to the level at which innovation occurs – Spam can be managed by hardware, software or behaviour. Personalised software spam filters afford more (better) protection to the individual but (perhaps) less collective protection or deterrence (because spammers are likely to reach 'someone[63]'). The physical analogy is a *commons* or an airport runway without marked lane lines – users can go where they want, but may run into trouble if they depart from conventional behaviour (i.e. the majority patterns of use).

Closed: at the opposite end of the open/closed dimension lie technologies, business relations and regulatory systems that restrict interconnection, mobility and variability. The advantages of a closed-system approach include the internalisation of externalities relating to e.g.

[62] For this reason, while the distinction between homogeneous and a differentiated technologies, and between the homogeneous or differentiated Internet experiences that may result is a key aspect of the future of the Internet, we do not view them as alternatives (hence key uncertainties or dimensions) but rather as impacts or outcomes.

[63] See http://news.bbc.co.uk/1/hi/technology/7719281.stm (on spammers' business models) and http://news.bbc.co.uk/1/hi/technology/7725492.stm (on the value of non-technological solutions to organised criminal spamming).

security, trust, reliability and other potential risks. The disadvantages include exclusion[64] of specific groups, the weakening of voluntary contributions and the potential foreclosure of transactions between 'insiders' and 'outsiders.' Closed technologies can also be homogeneous or diverse. A proprietary technology may dominate the market (e.g. Windows). It is less generative (cf. the 'converging-but-closing' nature of Internet devices); innovation is far harder (it is hard to get access to change – or even figure out how to change things) and 'gatekeepers' assert rights over productive innovation to control it for their own interests. Limited consumer mobility means higher prices (and possibly costs) than under an open regime. The upside is provision of 'club goods' to those in (identical) walled gardens. The physical metaphor is *toll road* – a space for travel and exchange shared by those who pay in order to obtain services that fit their particular characteristics and to ensure that they are most likely to encounter similar individuals.

Greater (though not necessarily better) diversity is likely to arise from fragmentation and limited consumer mobility. Monopolistic competition means deadweight loss[65] (possibly without excess profit) but potentially close match of technology to user needs. However, it is not obvious that 'needs' *for technology* must be different just because user preferences for services differ, so variations may not match needs but instead amount to 'mere variety' without justification or even 'IP lotteries' where differences reflect neither cost nor demand. The analogy is a 'small worlds' network in which average distances are very short, but local neighbourhoods are tightly clustered and tend to parochialism.

Note that the open-closed dimension is strongly influenced by a range of policy forces and instruments (public and private) controlling access to and application of these technologies. Of particular interest are intellectual property rights. Without rehearsing the vast literature on the subject, it is worth noting the ways different types of IPR influence openness. :

Patents create exclusive property rights for specified technologies and uses. As such, they are inherently closed. To the extent that they are controlled by dominant players and offer strong network externalities, they also favour 'sameness' in the sense of a dominant technological paradigm with high barriers to exit (alternatives would not be able to interact well with the installed base). On the other hand, if patent inspectors ensure that descriptions and protected uses are narrowly and precisely drafted, patents can encourage 'bypass' innovation. From the impact perspective, the key issue is the mix of

Diversity within the technology cluster paradigm (which makes the associated trend more robust and reliable);

Functional unity (avoiding inefficient variation); and

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[64] We note the ambiguities surrounding inclusion, exclusion and related concepts. The primary difference is whether individuals or groups find themselves 'outside the mainstream' by their choice, the choice of the majority and/or the judgement of third parties (e.g. elites). Secondary elements are: whether such separation serves the interests of those on the inside and/or the outside, whether the separation involves defined specific interactions and services or is general in nature, and whether separation is transferrable over time, place and circumstances. Finally, we note that these concepts are bound up with questions of identity, which is a form of 'belonging.' The analysis of these issues goes beyond our current scope, but it is appropriate to indicate the assumptions underlying normative judgements that inclusion and non-exclusion, for example, are ethically equivalent and socially desirable,

[65] See http://news.bbc.co.uk/1/hi/technology/7695624.stm for discussion of responsibility in the cloud.

Diversity across technologies, which can lead to faster innovation and greater functionality, or to a welter of unnecessary or inappropriately-applied variations.

Standards can be considered collective property rights, defined in a more limited way but shared among many entities. They can be open or closed (esp. proprietary); some standards bodies have adopted procedures (like the W3C RFC process) that amount to a form of self-regulatory open democracy. They also compete for compliance or official standing. This competition, like the competition among patented technologies, can lead to similarity (winner takes all) or difference.

Innovative forms of property right (exemplified by the GPL or CC content protection licence forms) are specifically designed to preserve openness (both in the sense that they provide open access to the protected content or technology and (more importantly) in the inclusion of a 'hereditary' aspect that ensures open access top derivative innovations. They have been associated both with dominant-paradigm (e.g. Linux) and diverse technologies; the interactions are complex and need further analysis from a range of perspectives as they evolve and evidence of their impacts accumulates.

2.1.2 Market Dimension: Competitive or cooperative attitude

A second key uncertainty concerns the balance between two opposed mechanisms or modes of societal engagement. These can be simply contrasted as *cooperation vs. competition*. Much has been written about these in relation to technology (e.g. standards vs. proprietary IPR), economic behaviour (e.g. collusion vs. market competition) and societal governance (e.g. joint action vs. democracy). As these examples make clear, each has (qualified) advantages and its own constituency. What is good (promoting the general interest) in one domain (e.g. cooperation in managing common societal problems or ensuring system reliability and interoperability or competition in matching demands to supply and ensuring fair prices) may be damaging in another (cooperation among collusive firms or 'race to the bottom' regulatory competition among governments). In the scenarios, this is interpreted as applying to the dominant domain: if the public sector dominates, then the competitive model is one of regulatory competition, with a possible danger of a race to the bottom - weaker regulation, favouring business interests over consumers (since businesses are more mobile) and restricted cooperation or harmonisation (thus resulting in greater international differences). Within and between countries, this type of competition and potential race to the bottom is likely to result in greater inequality.

By contrast, the cooperative model of public governance should result in efficient and active international trade, equivalent standards and greater equality in terms of GDP growth, employment levels, social capital, etc. From the modelling point of view, this entails economic convergence in aggregate, supported by a combination of national and sectoral specialisation and joint policies. Where the private sector dominates, the largely positive (or negative) view of cooperation (or competition) partially reverses; competition among firms should result in faster growth, better products, more rapid innovation, etc. By contrast, cooperation amounts to collusion, with exclusionary standardisation, profits growing faster than consumer surplus, restricted rate (and certainly distribution) of innovation and IPR, and closed or proprietary consumer relation models, which in turn should[66] strengthen inequality, especially along skill and income lines.

2.1.3 Governance Dimension: Public sector or private sector/citizen dominance

The third major uncertainty is whether development will be *dominated by public or private-sector interests*. Dominance by the public sector results in a reliance on rule- and law-based governance over markets, and heavy weighting given to such 'public good' interests as security, public service delivery, universality of services, etc. In relation to the economy, public dominance *ought* to mean a greater emphasis on competition (as opposed to market power) with consequently lower rates of profit. Growth should be slower but less volatile, levels of employment should be higher and wage growth should track profit growth. Also, the share of the public sector in both expenditure and (esp. RTD) investment should be larger. On the social side, progress should be more even – perhaps peak skill levels will rise less quickly, but will be more evenly distributed.

In terms of the global economy (and the coherence/effectiveness of the EU) there is something to debate in scenario analysis. Many would argue that public sector dominance should (via e.g. the plurilateral trade negotiation process) result in greater freedom of trade and more rapid convergence. But the failure of the Doha round suggests that protectionism is more likely under public dominance – this is certainly bad for efficiency (and thus for GDP growth and employment in aggregate) but may, paradoxically, result in a more even distribution, since the inherent advantages of the established economies and their rapidly-growing BRIC competitors mean that market opening often works to the disadvantage of less-developed economies. In particular, policy levers are key in establishing whether the kind of market opening pursued by governments will give small SMEs and producers of regionally-characteristic goods and services sustainable access to broader (European or worldwide) markets, their acquisition by MNEs (multinational enterprises), their disappearance as MNEs penetrate their home markets. It may even produce cyclical evolution as markets based on low cost and large volumes mature into a patchwork of richer, more diverse and often higher quality niches, which in turn consolidate, commoditise or succumb to entry by larger firms[67].

By contrast, private dominance will lead to more rapid, volatile and uneven GDP and employment growth. Depending on other scenario variables, this may lead to further globalisation (emergence of a truly international business community capable of much greater efficiency and more rapid growth, but beyond the effective reach of any regulation).

Taken together, these dimensions span those relevant possibilities that are not resolved by the trends themselves - in other words, the critical uncertainties that will determine which way the Internet of X unfolds.

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[66] This can be seen as a relatively simplistic view in which the public (private) sector consists primarily of public-spirited (resp. myopically self-interested) agents. Alternatively, the reader may prefer to interpret the public-private governance dimension as sunning from governance by collective interests to the struggle of powerful and selfish elites, regardless of whether they come from the public or private spheres.

[67] This sort of dynamic gives rise, to take a current example, to the rise and fall of 'long tail' markets and their diffusion from local to European\global scale.

2.2 Three Scenarios

The dimensions define a scenario space of possible future technology trends and socio-economic impacts, allowing us to analyse the implications of current developments and policy options without ignoring critical uncertainties. From a large set of logical possibilities, three particular scenarios were developed that combine relevance to important policy issues with *a priori* likelihood and face validity – in other words, they build in a consistent way on current knowledge, produce 'worlds' that can be recognised by key informants and emphasise specific 'macro-trends.' The scenarios are used to model economic and social impacts, which are discussed below. The ensuing impacts are thus dependent on the combination of the three dimensions; technology (open-closed), governance (private-public) and market (collaborative-competitive).

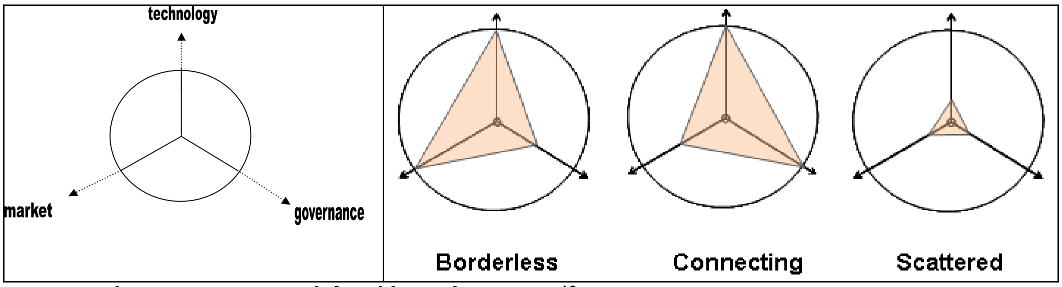

Figure 3: The scenario space defined by 3 dimensions[68]

The next section presents outlines of the scenarios in a narrative form to facilitate the reader's engagement in these fictitious future worlds.

Dimensions and socioeconomic aspects

The three dimensions above provide the basic skeleton of the scenarios. These are further populated by identifying variations in performance on a number of economic factors. These are expressed in Table 2, which shows how the variables were rendered as inputs into the International Futures (IFs) model used to assess future socio-economic impacts.

Table 1: Economic characteristics of the scenarios

Aspect	Open world	Connecting world	Scattered world
Openness	Open	Open	Closed
Governance	Private	Public	Private
Mode	Competitive	Cooperative	Competitive
Variety	Strong lock-in, tipping; some monopolistic competition	Modest 'paid' variety, high customisability	Excessive variety used for lock-in, market segmentation. Limited scale prevents many new developments.
Innovation	Cost-reducing innovation, rapid	Bottom-up innovation possible, also innovation	Excessive patent thickets, clusters and pools; mostly

[68] Graphic display provided by Prof. Guido van Steendam, participant to the scenario Workshop

Aspect	Open world	Connecting world	Scattered world
	introduction, rapid obsolescence	targeted on public needs – may be slow	top-down invention, 'closed devices' and limited scope for informal collaboration
Infrastructure	Little long-term investment, except in leading countries	Much 'connecting' infrastructure provides through public means.	Few countries can justify extensive roll-outs
Competitive mode	Concentrated infrastructure provision, 'branded' empires dominated by big MNEs.	Interoperability, low entry barriers produce effective competition in most layers	Cutthroat monopolistic competition, possibility of global collusion
Vertical integration	Low	High vertical integration, regulated for open access	High, facilities-based, walled garden
Public subsidy	Low	High	Variable and aligned with industry interests.
Inequality	Strong social divides by income, education, social advantage.	Inequality reduced among nations, but still high in some (between skill levels)	Elites do very well, but rising inequality within and among nations.
Labour			Local excess labour supply, low wages and job uncertainty, high unemployment and long spell durations
Regulation	Adequate locally, poor global coordination	Strong, effective guard against foreclosure	Weak, captured by dominant tech owners, race to the bottom
Global problems (e.g. financial stability)	Little progress due to lack of regulatory control or purchase	Possibility for new forms of partnership, regulatory coordination	Little progress due to lack of overriding identifiable common interest

Table 2: Scenario parameters relative to base case

Parameter\Scenario	Open	Connected	Scattered	Notes
Connectivity				
▪ Networking	*Fast*	*Fast*	*Slow*	Growth rate of networked persons.
▪ ICT impact (manufacturing, services, ICT tech)	*Broad*	*Broad*	*Broad*	Translates growth in networked proportion of population into growth rates in specific sectors to which network sectors diffuse.
▪ Internet density multiplier	*High*	*Status quo*	*Low*	Adjusted separately for World, EU 27
Governance				
▪ Economic Freedom	*Grows*	*Grows*	*Slow*	
▪ Democracy	*Converge to middle level*	*Converge to high level*	*Status quo*	
▪ Freedom	*More free*	*Free*	*Status quo*	Multiplier on Freedom House's measure of freedom (FREEDOM) which sums civil and political scales and also changes endogenously.
▪ Protectionism in trade	*Very Low*	*Low*	*High*	
▪ Productivity growth of system leader (Manufacturing, Services, ICT)	*Status quo*	*High*	*Medium*	Adjusted separately for Manufacturing, Services, and ICT sectors. Changes diffuse to productivity growth other countries.
▪ Elasticity of MFP w.r.t. Health spending	*Status quo*	*Status quo*	*Low*	
Government expenditures				
Adjusted separately for Leaders (OECD) and Followers (Non-OECD)				
▪ R&D spending	*High for leaders; slow for followers*	*High*	*Slow for leaders; fast for followers*	
▪ Education spending	*Fast for followers; slower for leaders*	*High*	*Slower for followers; fast for leaders*	Educational spending is further broken out across three educational levels (primary, secondary, and tertiary).
▪ Health spending	*Low*	*High*	*Slight increase*	
▪ Economic Investment	*Low*	*High*	*Status quo*	
▪ Welfare spending (for non-OECD/unskilled)	*Low*	*High*	*Status quo*	Government to household welfare (non-pension) transfers for social welfare.
Firms/businesses				
▪ FDI	*High*	*Status quo*	*Low*	Foreign direct investment
Individual behaviour				
▪ Work life	*Decreased*	*Status quo*	*Increased*	Labour force multiplier on retirement age
Distribution of wealth				
▪ Income distribution	*More equal*	*Less equal*	*Less equal*	Domestic Gini.

Variables in Table 1-Table 2 can be brought together into coherent, logical and sufficiently distinct stories of the future. The brief narrative of each future scenario is provided in the next sections.

2.2.1 The Borderless World of 2020

The Borderless World is free, open, and commercially-driven. It is a fluid, global world, where the fittest and 'fattest' (companies) and the richest (citizens) benefit most from mobility and opportunity.

The global economic collapse in 2008-2009 has had a dramatic impact and recovery has been slow and painful. National governments have been in a weak position to respond with effective stimulus packages to increase demand for goods and services by households and businesses. The recession has been deep and long but recently the world economy has picked up to an average growth rate of 2%. Today, government has little control and regulatory traction over the free market. Europe as an entity has started to decrease in relevance, as even at its significant size, it lacks the necessary scale to be a player at the global level, though it has attempted to position itself as the surrogate government for failing national powers.

Unfortunately, investments in large long-term infrastructure roll-outs have not been commercially feasible – due to the tension between the local base and global exploitation of such investments. Public subsidies and recovery support has been limited, and market agents have chosen to postpone such projects or to implement them in ways that reinforce market segmentation and 'non-neutral' discrimination among users and suppliers of complements (services, content).

Network industries are characterized by strong natural monopolies (oligopolies), providing proprietary infrastructures and a common technology paradigm (->Internet of Things). Interoperability is freely provided as a way to involve all potential rivals in the dominant firms' standards – increasing lock-in and switching costs, and creating a tendency for 'tipping'. Only revolutionary innovations that offer big visible and wide-spread benefits have managed to break out of existing lock-ins to lead to disruptive changes.

'Think global and sell global' has been guiding investment decisions. It has produced big (online) players where everybody shops. Being global in scope, they offer an overwhelming choice of life-style products and services. Brands and intermediaries have become increasingly important. Intermediaries offer specialised worlds that are formed around an exclusive selection of brands and styles. Quality of Service is likely to be ensured by the product or service provider. In August, the Olympic Games will be held in India. NokiaTendo has heavily invested in a global infrastructure and will host the first virtual Olympic Games – providing equal access and quality of service to every participant around the globe. The Games (offline and online) will be exclusively broadcasted by Tata News and provided as a premium service to its customers worldwide.

The Single Market has facilitated the development of an incident health care model. It runs on a large variety of commercially supported self-diagnostic tools, serving as a front end of a (commercial, pan-European) hospital system. Education has become much more service-oriented and companies have invested in education to make in the global battle for talent. In particular, lifelong learning has a strong job-orientation and become an important necessity to ensure employability. Demand and competition is high for branded on-line courses that facilitate portfolio careers. Overall, it has widened social divides between the rich and the poor, the advantaged and the disadvantaged.

Today we hardly experience the borders and boundaries of the past. We find that private eIDM solutions provide us with seamless access to service clusters globally, enabling mobility of work and leisure. Commercial social security schemes follow people around, without much social security for those that have not managed their affairs well or have little financial capacity.

2.2.2 The Connecting World of 2020

It is 6 April 2020; individuals freely interact in many online communities where they actively participate and play games; manage their private and working life. People rely on a strong public sector to create a common playing field and foster socio-economic conditions for consensus participation.

The public sector is large, active, focused on empowering its citizens and enabling innovation and productive collaboration. It ensures that business and citizens are well aware of their responsibilities, and follow strategies of active engagement. Government does not trust the market as it fears hyper competition and fragmentation. It sees itself as the guardian of the common good and provider of essential services. It also supports self organisation by opening up government information, and providing instruments like: quality scores on health care institutions and educational institutions, comparison of costs of living in specific neighbourhoods. Finally it is integrated in European and global multilateral governance structures to ensure free trade, productive collaboration and coordination and a reduction of cross-border inefficiencies. Europe is an attractive market for investment:

The public (-spirited) leadership that characterises this scenario strongly reinforces open standards, infrastructures and technologies, following the view that these stimulate innovation and productive competition (i.e. firms compete at application/services level and not at the level of infrastructure or technology). As a consequence a high degree of interoperability exists with low entry barriers for new services. Commercial and private initiatives have sprung up offering different services and applications to diverse preferences. This interoperability has been a powerful public good, which is guarded with legislation against the risk of foreclosure by 'bottleneck' firms or proprietary standards, using antitrust regulation, support for open standards and targeted public procurement to ensure a sustainable level playing field with high quality of service at reasonable prices. People are on line, and an important part of their lives is expressed in Web 4.0 environments:

However, the active or interventionist role of government has also affected the speed and depth of innovation – including the adaptability of policy to technological and market developments. The wealth of small initiatives does not always aggregate into deep and disruptive innovation; they often merely scratch the surface of what is possible. Governments traditionally do not embrace trial and error approaches, so delays are typical in the design phase of public e-services. As a result, even promising pilots never make it into the market because negotiated decision making leads to weak compromises and unclear specifications. The lack of competitive mediation (of the kind provided for better or worse by markets) allows the survival of e-services that 'miss the point,' being unsustainable, failing to address genuine citizen interests, etc when collaborative approaches are insufficiently ruthless or fail to listen seriously to citizens.

This world is very inclusive, using where possible the latest technology in combination with traditional service delivery (face to face, phone and paper) to engage people, especially those at the edges of society. By and large, citizens appreciate this and trust a professional government, as long as it is transparent and focused on public value creation. The majority have become complacent and expect government to take care of vulnerable parts of society. They tend to focus more on using on-line communities for work and social interaction, without actively participating in public policy setting and debates. Against this weight of passive consensus, even technologically enabled protest is relatively ineffectual; dissenters tend rather to 'opt out' into virtual (but specialised) enclaves.

There is plenty of work, and both the inclusive health care system and the lifelong learning support system make everybody as available for the labour process as necessary. However, economic growth seems to be flattening, specifically compared to those parts of the world where disruptive innovation has triggered step changes in development, even though this has led to higher overall volatility and the likelihood of boom-and-bust cycles. But Dr. Pangloss ("all is for the best in this best of all possible worlds") informs public attitudes in the comfortable environs of the settled 'developed' nations

2.2.3 The Scattered World of 2020

In the first decade of the 21st century, the advent of ever more efficient and ever more capable technologies spurred an explosion of innovative ways to connect, and to use connections both for existing purposes (e.g. communication, governance, commerce) and for an increasing range of new forms of interaction, starting with scripted massively multiplayer online role-playing games and primitive social networking sites and progressing to fully immersive virtual environments. Paradoxically, greater opportunities for interaction with others led – for a variety of reasons already visible in the late 2000's – to the erection of barriers. The 'reach' of technical systems, markets and societal interactions was restricted and individual users and stakeholders found themselves increasingly locked in to specific technologies, business models and social identities.

This separation was not (and was not always seen as) a bad thing. Arrangements preceding the emergence of the new technologies recognised the need for some limits to protect stakeholders from excessive complexity which might otherwise paralyse them or prevent effective and efficient decisions. Since an increasingly globalised world cannot escape reliance on individual and collective rationality, such limits became increasingly accepted. They offered additional benefits, promoting sustainability by compartmentalising issues or problems and thus rendering them visible and (in many cases) amenable to cost-effective and self-enforcing targeted interventions, especially in "small worlds" networks with 'broadband' social connections that join people in many ways and thus facilitate reciprocity and fellow-feeling.

In addition, localisation protected great diversity, particularly in the non-commercial uses of the Internet; *cultural expression* could hold its own against the levelling effect of *cultural production* and the strength of weak ties (the opportunity to learn or to teach something genuinely new to someone from another 'small world') was enhanced. Finally, local differences of behaviour, governance, etc. turned the world into a 'natural experiment' in which lessons could be drawn from clearly different experiences elsewhere, and the contributions of (visible) differences identified

On the other hand, the partitioning of the world was not designed or even agreed for a common purpose. Much of the decline in effective interoperability (initially at the technical level, but inevitably at economic and societal levels as well) reflected the parochial concerns of: owners of key technologies; service providers anxious to weaken rivals, lock-in customers and appropriate the benefits of trade between content users and content providers; governments keen to preserve sovereignty and discretionary power, etc. Predictable, widespread and cumulative adverse results included growing inequality and isolation both among and within countries and cultural groups, because limited or inhibited connectivity made exchange of ideas and coordination difficult or risky. Almost by definition, people saw themselves as more isolated than they were in fact; lack of interoperability does not mean lack of cross-impact. This can clearly be seen in the parallel and contributing reaction to the global economic crisis of 2008-2010. After an initial attempt to fix the blame on specific actors, the problem became widely recognised an emergent (and therefore undetected and unmanageable) consequence of a global financial system ruled by rapid and inexpert access to vast amounts of poorly-filtered and complex data. This was reinforced by natural political tendencies to ensure that national policy served national interests first and foremost, e.g. by re-erecting barriers to trade and to free communication and thus reducing international technical, economic and legal coordination.

Perhaps most importantly, the Internet itself became increasingly 'closed' and lost its 'generative' character – that emergent ability to adapt, learn, improve and ultimately to survive. New products, devices and modes of interaction could only reach small and parochial communities and thus many never achieved critical mass or moved from early adopters to larger acceptance. This lack of spreading weakened incentives to innovate and virtually stopped the bottom-up and 'crossover' innovation likely when one group starts (mis)using another's technology.

2.3 Tech trends' impacts in different scenarios

The technology trends identified in Chapter 2 contribute in different ways to the scenarios above. Table 3 indicates the main features of this contribution in terms of the impact mechanisms associated with the trends.

Table 3: Contribution of tech trends to scenarios

Trend\scenario	Open world	Connecting world	Scattered world
Infrastructure Convergence	Transparent, cheap, global communications, variable QoS; reduces vertical monopoly power.	Patchwork of interconnecting infrastructures, tiered QoS, variability in Universal service/access costs and provision. Potential global extension of facilities-based	Variable convergence levels, poor interoperability (by mode and region), costs rise, technology development distorted by 'extensive' competition. Reinforcement of regional monopoly. Potential emergence of new market

Trend\scenario	Open world	Connecting world	Scattered world
		competition.	domains not aligned with national boundaries.
Human-computer Convergence	Inequality based on enhancements (esp., in labour productivity), new global 'experience' industries, deeper interactive virtual environments – possibility of addiction (new source of monopoly power)	Access to both dangerous, productive enhancements coordinated by public sector.	Wide differences in availability, safety, acceptance between technological 'compatibility clusters.'
Utility computing	Open cloud model of computation, storage provided as public goods under Linux/OS-like model.	Location-based public utility regulation (extension of telecom regulation), possible excess capacity[69], extended Universal Service provision. Private 'grid' provision.	'Forked cloud' (closed proprietary) provision, limited mobility of data, computations; increased lock-in of computation-intensive users.
Intelligent Web	Control moves to centre of network and concentrates power in extended versions of current industry-civil society governance groups. Increased global market access for conforming entrants.	Restoration of end-to-end principle, with possibly greater participation of national governments in Internet governance	Concentration of influence at cyber-borders that reflect existing jurisdictional, sectoral and market boundaries. Creation of favoured network havens.

2.4 Summary

The three dimensions of technology, governance and market have shaped the scenarios. These describe possible future contexts for the Internet of X, and form the vehicle for assessing the socio-economic impacts it may generate. The next chapter summarises the economic, social and business model impacts associated with the three scenarios.

[69] Following standard Averch-Johnson effect if computing utility regulation based on rate of return)

CHAPTER 3 Impact Assessment: Economic, social, and business models

This chapter assesses possible future impacts of the Internet of X. At the outset, we acknowledge that the separation of technology from social and economic developments is a matter of convenience. There is no unidirectional causal relationship between technological and socio-economic trends.

The economic impacts are first assessed through a review of literature, then by applying our three scenarios to the International Futures model (IFs), taking the outcomes of this application back to the literature and our tech trends to draw out the connections between: the technology; the drivers of market development; the deployment of technology; and the possible impacts. For a review of future social impacts the study relies more on the literature and a framework developed in a parallel project of DG INFSO, run by the Universities of Siegen and Twente. However, the framework is modified to suit the prospective purpose of this study and certain social impacts have also been modelled with IFs and validated through the literature. Finally the impacts on business models are assessed through a review of relevant literature. Particular emphasis was given to the theory of technology lock-in and the ability to capture as well as create value. Lock-in captures the important idea that those adopting a particular technology or supplier may not fully take into account the limits this places on their future choices – in consequence, it cannot be assumed that these 'rational' choices lead inexorably to better outcomes *even for those with power to choose.* The distinction between value capture and value creation allows us to differentiate apparently similar business models and to place the relation between the rational behaviour of commercial enterprises and the welfare-seeking aspirations of market-based societies (the so-called invisible hand) on a sound analytical footing appropriate to future internet market environments

It is important to emphasise a number of aspects of the use of scenarios in relation to policy assessment:

- The scenarios are each compared to a base case representing the most likely outcome if all currently measured trends continue in the directions they are going. This is implemented by running the IFS model without any modification of the parameters from their default settings.
- Although each scenario presents a holistic picture that involves a specific policy stance, the scenarios do *not* correspond to policy choices – rather, the policy assumptions in each scenario correspond to the policies that would be chosen in the indicated scenario.

They are thus either consequences of the scenarios (in other words, protectionist policies are a characteristic of the Scattered World, not a cause of it) or a possible coping mechanism within the scenario. Policies are not the same as scenarios nor a guaranteed way 'out' of them;

- By the same token, these scenarios represent global rather than region-specific perspectives. To some extent, this is already encompassed in the scenario analysis[70]. It would be possible to model more extensive 'opt-out' situations in which (e.g.) the European Union followed a 'Scattered World' policy isolation while the rest of the world followed the 'Borderless World' scenario, but the game-theoretic analysis of these situations and the self-consistent nature of the scenarios argue strongly that such 'asymmetric' outcomes produce a large number of alternative futures with few sustainably policy-relevant differences. Rather, we analyse individual policy aspects most closely related to the issues arising.[71]
- Treating the three scenarios as policy strategies (policies of openness, managed connectivity and isolation corresponding to SW, CW and BW, respectively), the importance of connectivity, interoperability and globalisation indicate that symmetric adoption of consistent policy strategies in all areas are equilibria. Moreover, even starting from an asymmetric starting point, evolution (incremental and reactive policy) can lead the world towards one or the other symmetric scenario. Nevertheless, in view of the very different impacts in the different scenarios and the dynamics of policy evolution, there may be windows of opportunity for far-sighted leadership to alter, for example, the slide into fragmentation. However, this may well be prevented by short-termism because it will likely cause short-run losses or vulnerability to risk.
- This leadership potential means that EU consideration need not be limited to the assessment of unilateral policy changes. Leadership can change world policy, not least because a policy stance that works with the grain of technological, economic, societal and political evolution can encourage global policy changes. Specific policy initiatives can be configured as quid-pro-quo policies (e.g. by commitment to explicit reciprocity via most-favoured-nation deal or 'equivalent protection' wording in Directives that extend the benefits and reach of Single Market Policy. The EU can also encourage Member State policy change and (to a lesser extent) private sector policy change

3.1 Assessing economic Impacts

This section first reviews the literature and briefly discusses the state of the art in understanding the relationship among ICTs, 'connectivity technologies' and economic indicators. Then the scenarios developed in Chapter 3 will be applied to the IFs model, by rendering the input variables to reflect the nature of the scenarios. The results of model runs are presented and placed in the context of current understanding of these phenomena in the

[70] For example, in the Connecting world of 2020 (2.2.2 on p. 43) we note that growth in the EU has slowed relative to those places where more disruptive technologies have been allowed to emerge.

[71] Hundley *et. al.* (2003).

literature. Finally the economic impacts generated in the three scenarios are related back to the tech trends. The analytical framework is described in Appendix C: including a discussion on the possibilities and limitations of the chosen methodology.

3.1.1 Framework for analysis

The economic impacts must be understood in the context of the project as a whole – it is neither possible nor desirable to *predict* either the contribution of specific technologies to economic development, or the associated socioeconomic trajectories. Neither is it useful to restate the entire corpus of literature relating to the economic impacts and determinants of technology. The world economy is too complex for this to be a manageable or meaningful enterprise – there are an enormous number of increasingly-coupled feedback loops whose emergent collective behaviour increasingly confounds prediction even at the most highly aggregated level.

Most existing models and data sets are not entirely appropriate for this sort of analysis – they tend either to concentrate on highly specific individual technologies (like broadband, email) or market sectors (telecommunication) or to take a broad-brush – even generic – approach to ICT. This is necessary for econometric models in order to balance data weaknesses against predictive validity, but does not provide the kind of insight into overall systemic effects needed for the purposes of this project. As a result, the impact analysis is primarily conducted using the International Futures System (IFS) scenario modelling/visualisation tool.

The economic impacts are assessed in the following framework. The technology trends and scenarios described in the foregoing chapters are analysed in light of known results from the economic literature in order to determine their likely effects on the key parameters of the IFS model and to identify the most relevant output indicators.

The steps involved in assessing economic impacts are as follows:

Identifying key model/policy parameters affected by the technology trends and scenarios and the most relevant output indicators;

Describing the channels through which technology trends affect key economic impact variables;

Discussing the contribution of each technology trend to the three scenarios in terms of the underlying dimensions defining the scenario;

Rendering the scenarios in terms of IFS model parameters;

- o The IFS production function uses input indicators to drive productivity parameters. In this study, for instance, policies relating to education and health expenditure affect human capital quality, while networking and technology indicators affect multi-factor productivity. Impacts on GDP growth, productivity, inequality, etc. are measured by simulating the world (socio) economic system from the present to 2020.

- o Within each scenario we will also focus on regional comparisons among EU15, EU27, North America, Japan and Korea and the BRICs.[72]

Running the model for the base case and the three scenarios;

Conducting sensitivity analysis on the parameters and assumptions;

Producing the output measures/indicators for subsequent analysis[73];

Assessing the pattern of impacts for *each* scenario;

Comparing results across scenarios;

Reviewing outcomes against general economic theory and specific research done by our sister project, "The Economic Impact of ICT" SMART N. 2007/0020[74]

Developing an overview of the results: likely emergent policy issues; implications for the impacts of (especially economic) policy; and relation to exogenous developments.

IFS suits the purposes of this study[75] because its wide range of input parameter values provide a sensitive interface to the complex interdependencies of the macro-economy. Its accessibility and flexibility are of continuing value in preparing this study and for extending to investigate other scenarios, for incorporating new data and assessing specific policy proposals; additionally, the publicly available source code facilitates modification to explore alternative mathematical relationships between uncertainties, levers and measures. In particular, because IFS is a general equilibrium model, it offers a valuable point of comparison to the more common partial equilibrium models used in much of the literature: perhaps the most essential characteristic of the Internet Society is its complexity – the importance of systemic interactions in shaping future evolution. General equilibrium models are precisely intended to capture such interactions – perhaps not the full complexity of the real world, but certainly much more than partial equilibrium neoclassical models, whose more precise econometric estimates form a valuable complement[76].

[72] Turkey and other accession countries were not included as the timing and conditions of entry we cannot predict despite the big influence they would have on the analysis

[73] This Chapter reports a subset of these data; a full database is available.

[74] The results seem to be in broad agreement, but full validation has not been completed for this draft (full results are not yet available and further discussion is needed to reconcile the different levels of aggregation, modelling strategies and specificities of the two studies.

[75] Although adding detail can give the impression of greater completeness and more insightful examination of detailed policy levers, it may not usefully reduce uncertainty: no additional level of detail can ever produce reliable predictions of an unpredictable future; errors in the data may outweigh additional resolution; comparisons become harder; and highly nonlinear innovation competition and other policy mechanisms are not 'smoothed by aggregation.' The approach taken here is to use the model to give the overall shape of impacts, reserving detailed discussion for workshop scenario analysis.

[76] The current EC-sponsored development of IFS is deepening the treatment of ICT in order to: 1) shed greater light on the long-term drivers of ICT adoption and diffusion; 2) improve ICT adoption and diffusion forecasts; 3) further endogenise ICT as a sector of production within the IFS economic model; and 4) better integrate energy consumption and ICT.

The objectives of this forward-looking scenario analysis are to identify the principal mechanisms of this complex system and to assess impacts associated with their operation in order to:

1. Characterise economic impacts likely to require or trigger policy actions in a broad sense;
2. Develop an understanding of how the technology trend/scenario combinations considered here are likely to affect the role of economic policy instruments; and
3. Provide a basis for adapting broader policy analysis to new circumstances that might arise (e.g. the current global economic instability).

The analysis is also accompanied by numerical impacts computed using specific economic modelling systems. It is important to take into account that model results are not facts or even predictions, but assessments of how things are likely to change in the different scenarios. The model results should be approached in the spirit of calibration and as a way of testing robustness, raising the possibility of otherwise-unforeseen consequences and increasing the resolution of scenario analysis to deepen understanding (esp. of who benefits). The model results should therefore be viewed as primarily ordinal (indicating whether things go up or down) and to a limited extent as 'semi-cardinal' (indicating whether they change a lot or a little).

3.1.2 Some relevant literature on economics and the Internet (unmodelled impacts)

This section captures some relevant findings from the literature that informed the adjustment of parameters in the IFS model to capture specific aspects of the technology trends and the scenarios and to provide 'stylised facts' useful in the assessment of unmodelled impacts. It is based on the work of our sister project, "The Economic Impact of ICT" (SMART N. 2007/0020),which is dedicated to synthesising the existing knowledge about the function of ICTs in the economy and using bespoke data sets to address some of the traditional challenges in the literature. Here we summarise and extend some highlights. We note, however, that this discussion goes beyond the scope of our study, which limits attention to the connectivity aspects of information technologies. We have organised these findings into four categories: *general findings; growth and productivity; distribution; and labour issues.*

General findings

The state of art in the understanding of the internet revolution's impact on modern economic life has drawn on nearly every aspect of the discipline of economics. Rapid changes at every stage of the production process contribute to theoretical, methodological and empirical gaps in the literature that leave many questions with ambiguous answers. The next paragraphs indicate the main areas of agreement, and also those areas of ambiguity associated with them. This should not be read only as a disclaimer; substitution effects and tradeoffs identified in the literature[77] that are difficult to assess at the macro level or isolate the effects of at the micro level also 'open the door' to a more futures-orientated analysis.

[77] For details, see van Reenan et al (2009)

There is general agreement that ICT consistently appears to have strong, significant and pervasive effects on virtually every aspect of the economy. The greatest impacts of the internet are on *prices across countries and industries* (reducing transaction costs, information costs, increasing transparency, comparability of products and prices, etc.). However, more precise insights into ICTs and their impacts are difficult to model due to a lack of suitable data[78] and weak theoretical understanding of the true causal linkages between ICTs and economic outcomes.[79]

The issue of *complementarity or network externalities* plays a very large role in the literature and in this study – even more than in the general range of ICTs considered in van Reenen et al (2009), the Internet tech trends identified here have both direct and indirect network effects[80]. It is intuitively the case that single standards and maximal connectivity should maximise network benefits. However, this suggestion is too simplistic – the advantages of homogeneity and network growth can be counterbalanced against the benefits of variety, differentiation and resilience and the disadvantages of the tipping equilibrium problem and excessive (compared to social optimum) volatility and inertia in adopting new technologies[81]. Overall, adoption may be inhibited by fear of lock-in leading to high prices, restrictions on access to complementary or alternative products, lock-in to obsolete services or enforced transition to new services with associated performance risks and adjustment costs.[82].

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[78] Especially at the micro level across countries and industries. What data exists is limited to hardware technologies.

[79] For example, ICT and productivity are positively linked, but each appears to 'cause' the other. The endogeneity issues that might explain this have been little-studied and there is a lack of solid links, aggregation or disaggregation methods for data at different levels: micro (establishment or firm); meso (region or sector) and macro. As a result, micro studies risk overestimating productivity impacts whilst macro studies underestimate such impacts.

[80] Direct network effects - utility derived from consumption of network is affected by the number of other people using similar or compatible products and utility increases when there are more users to communicate with), and indirect network effects - utility depends on the availability of complementary goods which in turn depends on the number of potential buyers e.g. software running on a computer which consists (at least) of an operating system and applications software.

[81] Shapiro and Varian (1999), Katz and Shapiro (1985, 1986 and 1994).

[82] The existence of significant network effect in ICT has several implications for market structure and their impact on firm productivity:

1. Market concentration - markets with strong network effects such as computer software may be inefficient because they show a tendency towards monopolisation e.g. Microsoft despite the fact that classical entry barriers seem to be fairly low, especially for software markets where no physical infrastructure has to be built. There are larger network effects that arise from having a single dominant network, and it is unclear whether dominant players in network industries charge monopolistic prices.

2. For complex and complementary goods, market dominance may be translated to other product groups e.g. PC and server operating system

Network effects may delay technological progress because a strong installed base may make it relatively more risky to adopt a new technology without a similarly sized installed base. Thus excess inertia may actually delay the adoption of new software technologies and infer more power to whoever sets the first standard.

Growth and productivity

There is a large, positive and significant association of ICT with *productivity*. Indeed, the main productivity drivers have been rapid technological progress in the ICT producing sectors, a rapid fall in quality-adjusted prices for ICT goods, uptake in ICT-using sectors[83] and organisational capital[84]. Since 1995, European productivity growth has remained level whilst the US has accelerated. The key difference seems to lie in the stagnating productivity of European ICT using sectors, which is surprising given the similarity of ICT prices around the world[85]. Other suggested explanations include: the difference is transitory and Europe will catch-up; long-term structural problems in Europe such as over-regulated and inflexible labour and product markets; lack of product and labour market integration; lagging European investment in complementary organisational capital; and a European investment and regulatory climate that is less friendly to the complementary (formal and informal) innovation needed to realise the full benefits of ICT investments[86].

Beyond this, much of the recent growth in productivity is associated with the transition to a so-called 'knowledge economy.' ICT is a major catalyst; it has reduced the costs and constraints of collecting and disseminating information and improving communication, which in turn increases the efficiency of collaboration and has generated even more knowledge. Knowledge intensive industries (KIS) such as professional services (finance, legal services, recruitment, management consulting, marketing) are central to the knowledge economy because they are advanced users of knowledge and because they provide important service inputs to other industries. So knowledge based products are important both as final-demand products and intermediate goods[87].

Distribution

One set of findings concerns the spatial (urban/rural, international) *distribution of ICT-related economic activity*. ICT may be spreading overall activity across cities and countries, but business functions are increasingly spatially concentrated within that overall distribution[88]. The spatial effect is not straightforward to assess empirically because of a range of tradeoffs and substitution effects identified in the literature. These include the following:

1. *Centripetal vs. centrifugal forces:* advances in ICT reduce transaction costs in trade and communication and should therefore spread economic activity more evenly across space, especially in pursuit of lower input costs and higher demand levels in other areas. However, even in an ICT-rich economy there are benefits to physical proximity. These 'agglomeration benefits' include greater spillovers, human interaction and learning, the co-location of complementary activities and the

[83] E.g. retail, wholesale and finance.

[84] E.g. decentralisation of: firms and returns for ICT investment in multinationals, which could also explain strong US-European differentials in the productivity of similar ICT investments.

[85] van Ark *et. al.* (2003).

[86] Aho, 2006; Cave *et. al.* (2008).

[87] The analysis here lacks a clear classification of KIS and internationally comparable microdata

[88] This is reinforced by the similar concurrent effect of globalisation.

tendency for a 'critical mass' to produce enhanced local access to human capital, favourable regulatory conditions and finance. In addition, as noted above, some of the tech trends are based on the provision of local (shared) physical infrastructures, which are by definition agglomerative.

2. *Access to customers vs. higher competition*: Reduced transaction costs may also have ambivalent effects on firm location decisions - better access to concentrations of customer demand comes at the cost of relatively higher competition from other firms.
3. *Functional specialisation and outsourcing vs. higher demand for managerial services and innovative activities*: Falling ICT prices and reduced transaction costs make it easier to shift manufacturing and services away from cities to areas with cheaper labour supply, but managerial functions tend to become increasingly concentrated in metropolitan centres and countries with well-developed legal frameworks due to "agglomeration effects".
4. *Reduced need for face-to-face relationships vs. increasing scale and scope of relationships*: ICT availability makes it easier to communicate and coordinate activity without the need for personal meetings, but as the costs of maintaining relationships goes down, people will be able – and even forced - to support more relationships which may create the need for further personal contact. At the individual level, ambivalence has been particularly noted in relation to the impact of ICT on transport.

A second set of observations concerns the distribution of impacts across persons. Much of this concerns social capital and welfare and is addressed in the next section of social impacts, but it is worth noting here that digital divides of various kinds affect the opportunities of individuals and businesses to take advantage of potential ICT gains. There are many demographic, economic and institutional correlates of digital divides across regions and countries, which are often not directly related to ICT access. In addition, digital and other (e.g. educational, income, cultural) divides are often mutually reinforcing.

Both spatial and personal distributions are affected by *globalisation*. Multinational corporations (MNCs) enjoy a productivity advantage over domestically owned firms (in terms of capital intensity, skill intensity, and scale of operations in terms of:

- Better use of ICTs due to greater organisational flexibility, higher ICT investment and organisational structures that are complementary to ICT usage;
- Increased use of outsourced and offshore services due to intensive ICT use; and
- The significant roles of foreign direct investment (FDI) and MNCs in driving the international convergence of ICT-intensive sectors.

The overall impact of ICT-driven globalisation on the economic competitiveness of firms is fundamentally shaped by the *international trade environment*. In particular the divide between the developed 'North' and the developing 'South' depends on the relative competitiveness of firms and in turn on their productivity[89], market access[90] and level of

[89] Acemoglu (2007)0.

[90] This depends both on e.g. trade policy and on national versions of the digital divide.

domestic competition[91]. Due to the winner-takes-all character of global competition in ICT using sectors, this *polarity in economic well being* has increased as the world economy becomes reliant on information technologies. Additionally, the global networking of financial markets and 'weightless[92]' mobility of economic activity have produced excess volatility that not only favours developed nations (and firms based there) but also favours the deep pockets of larger enterprises (and the countries in which they are based).

Finally, levels of innovation and the location of economic activities are mobile: firms located in one area who face rising competition from high-tech import penetration can pursue accelerated "defensive innovation" strategies or relocate their low-tech (high-tech) tech activities to the global South (the term used to describe the less-developed areas of the globe) (resp. the global North) or to form extended international collaborative networks.

Labour issues

ICT has redefined the meaning of work and changed the *social purpose* of employment. ICT-based employment allows greater interactivity. This is conducive to collaborative innovation and can enhance the social character of work, but equally may reduce personal contact through remote working and outsourcing. The reshaping impact of ICT is particularly pronounced in the service sector, which together with business employment, has expanded as manufacturing jobs have declined (especially in the 'leading adopter' nations of Europe).

Increased *labour market efficiency*[93] and transparency have facilitated better matching of workers and skills and enabled more flexible working arrangements for e.g. disabled workers and those needing to care for children or ageing relatives. ICTs have lead to the creation of more jobs and new kinds of jobs. However due to technology substitution and job displacement there is also an off-setting negative effect on overall employment, which has declined (though this cannot all be attributed to ICT diffusion). The greater substitutability of service workers in terms of skills and availability has sharpened competition and (particularly in call centres, for example) produced measurable *declines in real wages and job security* (even before the current troubles).

ICT also affects the *distribution* of employment. Compared to manufacturing or extractive-industry jobs, for example, ICT employment is less prone to gender and age imbalance, more conducive to flexible and remote working and less physically demanding. However, these benefits are offset by other biases. ICT favours high skilled workers (raising their already high wages) at the expense of the lowest skill groups – the most adversely affected being those in routine occupations and those with only minimal education. On the other hand, the organisational changes (including workplace training) associated with ICT adoption often offers greater benefits to those with the lowest prior skill investment; certainly, the skills bias increases the (relative) return to education and should encourage

[91] As Porter (1990) notes, global competitiveness requires a domestic base that is to some degree cooperative (to ensure the development of common resources and the sharing of knowledge) and to some degree competitive (to 'toughen' exporting firms for the global market environment).

[92] Quah (1999).

[93] Bayer, Ross and Topa (2008).

greater uptake. ICT also favours the young[94] at the expense mainly of those aged 50+ due to inherent capabilities of young (flexibility, eagerness to learn) and the reduced 'payback period' for training older workers.

It is useful to distinguish the *quantity* of work from the *quality* of work[95]. The use of ICTs has increased quantity through general macroeconomic impacts (raising overall productivity, stimulating trade, increasing disposable income, etc.). Some of these new jobs are skill-intensive and rewarding, but most (in numerical terms) are not: many formerly-scarce IT skills are now common in the workforce (at least in advanced countries) and many jobs created by ICT demand very few skills. Much the same can be said of some 'core' jobs, where the diffusion of 'user-friendly' tools for e.g. programming and web design has reduced skill requirements, sharpened competition and cut pay and job security. As noted above, substitution of ICT for labour quality or quantity is exacerbated by globalisation.

Growth Accounting

The underlying analysis of productivity and macroeconomic impacts of technology adoption in IFS (and much of the literature) is based on growth accounting. Growth accounting seeks to explain patterns of GDP growth in terms of underlying inputs, recognising feedback and double-counting relationships – for instance, that capital formation is both a driver and a component of GDP growth. This is particularly true of the inputs that arise as outputs of the policy aspects identified above, due to the linkages among those policy aspects. GDP growth is decomposed as a sum of growth rates of factor inputs (labour and capital) weighted by their shares in total income or costs. GDP growth that cannot be explained in this way is referred to as the growth in Multi-Factor Productivity (MFP).

MFP is a residual, so it incorporates market and regulatory conditions, sector-specifics and other influences known to have important effects. It can be 'explained' by many variables, including venture capital, diffusion of basic research, globalisation, trade openness, etc. These results make it hard to attribute growth to specific causes. At an aggregate level, both capital formation and MFP played major roles in GPD growth. Recent growth accounting, beginning with beginning with two seminal papers, one by the OECD[96] and one by Colecchia and Schreyer[97] adds ICT to capital and labour as a separate factor because of its complementarity with other inputs, general-purpose nature and particular challenges associated with its measurement. At a deeper level, van Ark and colleagues[98] have been studying ICT - labour complementarity, specifically ICT contributions to the growth of labour productivity. They identify two channels: *capital deepening* - increase in capital intensity normally measured by capital stock available per labour hour spent; and *total factor productivity* (TFP) resulting directly from ICT-goods production. They find that the sustained US labour productivity advantage is almost entirely explained by these effects; intra-EU differences in performance are primarily driven by non-ICT differences. In the IFS

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[94] Card and Lemieux (2001) - Confirmed by wage share regressions using EUKLEMS data

[95] esp. remuneration, security, intrinsic rewards, opportunity for growth sense of control, etc.

[96] OECD (2001).

[97] Colecchia and Schreyer (2001).

[98] See e.g. van Ark *et. al. (2002)*.

model, MFP is obtained as a residual after (quality-adjusted) adjustments for labour and physical capital. IOCT capital is not separated due to data problems, so forms part of the MFP residual, which is further decomposed – using correlated indicators – into the contributions of human capital, social capital, knowledge capital and 'common' or infrastructural physical capital (transport, electricity, Internet and Telephones).

These findings generally refer to an undifferentiated diffusion of ICT and implicitly emphasise different impact mechanisms depending on the technologies of most relevance to the different studies. In order to place them in context, Table 4 identifies the mechanisms associated with each of the four trends identified in the present study.

Table 4: Tech trends in relation to 'general ICT' impacts

	Impact mechanisms
Infrastructure Convergence	Increases communication, facilitates outsourcing and access to remote customers, reduces need for duplicate investment, lowers communication service prices, raises quality of service, reduces cost of search and thus cuts price disparity. Impact of welfare depends on scenarios via openness and connectivity (how much, who controls).
Human-computer Convergence	Creates new sector of economic activity, may damage other experience goods, potential to enhance labour productivity, possible displacement effect, risk of deepening digital divide between enhanced and normal, increased skill bias in employment.
Utility Computing	Lowers extent, cost of necessary business ICT investment, levels competitive playing field between large and small enterprises, may weaken business case for providers of embedded computing services (intermediaries) if an open cloud prevails, may produce increased rents if a proprietary grid prevails, increases demand for telecom services, possible increase in skill bias.
Intelligent Web	Complementary to Infrastructure Convergence and utility computing trends, may enhance power of platform intermediaries (policy and scenario dependent), little impact on employment.

3.1.3 Future economic impacts assessed in each scenario

The three scenarios are projected against a base case, which is a projection whereby all variables in the models remain untouched (a description of how this base case world would look is given below). Thus the particular relevance is the relative variation of each scenario compared to this base case.

Describing the base case across regions (EU, North America, BRICS, Japan and Korea)

The base case projection shows:

- The *impact of the current recession*, is represented in the base case albeit in muted form.
- *Network infrastructure* is projected to rise, but at a decreasing rate. The EU is rising most quickly, with EU15 projected to overtake Japan & Korea by 2014 and the US by 2021.

- *Telephone infrastructure* (including new technologies) is also expected to rise. The EU15 is already ahead of North America, but is overtaken by Japan & Korea in 2015. In both infrastructures, the BRICs lag far behind (due to large and rising population numbers) and show no signs of catching up.
- In terms of the *proportion of networked persons*, all nations show growth, the EU catches up to Japan & Korea by 2014, but grows less rapidly after 2017. Nonetheless, EU15 overtakes the US by 2020, largely because the US network growth shows signs of saturating at about 2/3 of the population.
- The EU groups retain their lead in *globalisation* throughout the forecast period, though by 2023 Japan & Korea have overtaken the US and are beginning to narrow the gap.
- US progress in terms of *government effectiveness* flattens out through the period, and it is overtaken by both the EU15 and Japan & Korea in 2019.
- In terms of the composite *Knowledge Society index*, however, the US maintains its lead over the other groupings at least until 2024, when it is overtaken by Japan & Korea. While EU progress accelerates somewhat (in both EU15 and EU27, which remain close throughout the period), its rate of advance remains below that of Japan & Korea and the BRICs (who are nonetheless still well below the EU even out till 2025).

Inputs

- *Government expenditure* remains high in the EU aggregates, despite the 2008-9 hiatus, growth is forecast to resume and remains above that of other groupings, being roughly parallel to growth in the US, faster than in Japan & Korea, but slower than in the BRICs.
- *Investment as a share of GDP* is forecast to decline in the EU, though not as steeply as in Japan & Korea. They, however, start from a level 65% higher, which only drops to 44% higher by the 2025. US investment is predicted to pull away from EU levels, rising from 22% above the EU in 2005 to 60% higher by 2025. In the BRICs, investment remains fairly stagnant, but the gap closes from a 52% shortfall (compared to EU27) to 34% by 2025.

Multifactor productivity

- *MFP* is fairly stagnant in the US (around 2.5), the EU (around 3.18) and Japan & Korea (around 3.28). In the BRICs, it grows from near-US levels to convergence with the EU by 2025. But6 the picture changes when we examine the MFP components.
- The *human capital contribution to MFP growth* is highest (and growing) in the EU, while it falls in the US after about 2010, in Japan & Korea after 2013, and in the BRICs throughout the period, having already turned negative by 2007. All economies show a dip in 2009 as a result of the recession.
- The *contribution of knowledge capital to MFP growth* is high and stable in the BRICs and Japan & Korea (between .4 and .5), but in the EU and the US it is negative (though rising after 2016).

- The *contributions of physical capital to MFP growth* are also negative in all except the BRICs, with much steeper recession trough (compared to knowledge capital). It thus appears that Europe's superior performance is largely driven by human capital.

Output

- *GDP* grows throughout the period in all regions, but at a faster rate in the US and the BRICs (which overtake the EU15 in 2022 and EU27 by 2024.
- *Correcting for population size*, the EU15 remains sandwiched between the US (on top) and the BRICs (where growth is much slower. Japan & Korea manage to increase per-capita GDP at a faster rate, overtaking the EU15 by 2015.
- In terms of *growth rates*, the BRICs and North America are least affected by the recession, and rapidly regain growth rates of 7% rising to 8.5% (BRICs) and 4% easing to 3% by 2025 (North America). By contrast, the recession is longest-lasting in the EU and sharpest in Japan & Korea, with both groups stabilising around 2.5% by about 2012.

Inequality and power

- *Inequality* (measured by the domestic Gini coefficient[99], which is higher in less equal societies) remains fairly stable in all major regions, but at different levels: highest in the BRICs (43%); followed by the US (40%); the EU 32%; and Japan & Korea (26.6%). Within the EU, inequality is declining until about 2015, when the maturation of economic development and increases in productivity relative to demand growth lead to greater income inequalities.
- The index of *national power* shows the waning influence of North America, which is overtaken by the BRICs in 2014. The power of the EU (higher in EU27 than EU15) is declining throughout the period at a steeper rate (EU15 -32%, EU27 -30%) than either North America (-6%) or Japan & Korea (-19%).
- On the other hand, the *technology power* of North America remains the highest and fastest-growing, with the EU aggregates in second place maintaining a stable lead over the other regions.

[99] The Gini coefficient is the most widely-used measure of inequalities in income (and other variables). It is generally computed from the Lorenz Curve (a plot of the population from poorest to richest showing the cumulative proportion of the population on the horizontal axis and the cumulative income on the vertical axis). The Gini coefficient is the area between the Lorenz curve and the (45°) line corresponding to perfect equality, as a proportion of the area under the 45° line – equivalently, it measures the average difference in income as a proportion of the average income. It is particularly well-suited for comparisons among groups or countries, being based on a ratio analysis and capturing (albeit in a simple way) the population as a whole rather than, say, GDP per capita. It is worth noting that the Gini captures much more than government policy: for example, the EU has a relatively low Gini coefficient (meaning high equality). This is surprising, since the EU has virtually no interstate income redistribution power (the EU budget is ~1% of total GDP and there are no EU taxes, social policy or treasury) and in view of the recent accession of poorer new member states. The 'Gini coefficient for the EU' is computed on an EU-wide basis, rather than as an average of the Gini coefficients in the individual Member States. This approach was taken to analyse the EU as a single socioeconomic region.

Borderless World

Framework conditions

In the Borderless world, European *network infrastructure* rises even more rapidly, reflecting both demand-pull and supply-push influences of newly-accessible world markets. Its growth exceeds base case projections by 45% by 2015 (and growing slowly, parallel to the base case, thereafter). The BRICs and North America slightly outpace the base case, but primarily as consumers, while Japan & Korea experience virtually no additional growth. In contrast, and as a direct result of market conditions that favour the internet over telephony, the *telephone infrastructure* grows more slowly than in the base case, although growth picks up again after 2015, when new technologies come on-stream. Improving general economic conditions accelerate telephone infrastructure in the BRICs, but all other regions show slower expansion. This slowing is least in North America, where the greater attractiveness of the Internet is partially compensated by a greater emphasis on (telephone-based) domestic activity. The *rate of saturation* (growth in % of networked persons) is slower in the EU and in Japan & Korea, and in North America after 2014, but slightly faster in BRICs.

Europe is able to exploit its access to world markets even more effectively once connectivity barriers based in overseas technology are reduced. *Globalisation* for the EU aggregates (EU15 and EU27) rises by 15% between 2009 and 2015, levelling off to a slow but steady growth thereafter, reaching 18% above base by 2025. Globalisation also rises in North America and the BRICs, but at a much slower pace, rising 3% above the base over the next 2 decades. Japan and Korea are displaced during this expansion. *Government effectiveness* grows, but is (as expected) lower throughout the Borderless World, except in the BRICs, where it grows along with market power. In the EU aggregates, it grows much more slowly until 2015, when it slowly begins to accelerate again (though remaining well below the base case). Finally, the conditions of the Borderless World slightly slow the rate of *Knowledge Society Index* growth everywhere except in the BRICs, where the result is a modest (< 2%) acceleration.

Inputs

Both in order to take advantage of the new openness of world markets and to respond to the social expenditure challenges posed by globally weightless commerce, *government expenditure* accelerates fastest in the EU, trailed by a more modest acceleration in North America and Japan & Korea (primarily driven by welfare payments). It accelerates in the BRICs, but only very slightly, as most of the cost of supply-side expansion is met by newly-successful globalised players homed in this area. This is confirmed by rising proportion of *private investment* as a share of GDP in this scenario – it was effectively flat in the base case (at < 1%) but rises in the Borderless World, even overtaking the EU figure by 2022. Disappointingly, the decline in private investment in the EU worsens in the Borderless World. Japan & Korea fall even faster, but from a much higher level, and they manage to reverse the decline by 2022.

Multifactor productivity

MFP remains static or declines slowly in all regions except the BRICs, which accelerate from North American levels to approach EU27 levels by 2025. The EU sees a slight downward shift in MFP in this scenario, largely as a result of the migration of cheaper jobs overseas (the growth of overseas supporting physical capital). Somewhat worryingly, MFP growth in the EU15 remains at a high and accelerating level, while growth in the EU27 falls from 2008 through 2016 (in response to internal labour and work migration and relative economic development) before resuming growth. This impression is confirmed by the specific factors analysis; the *contribution of EU human capital* to MFP growth is substantially higher in the Borderless World, but the strong contributions of Knowledge capital in the base case are reversed as knowledge flows overseas. This phenomenon reflect two factors; European knowledge is being exploited overseas (so its contribution is counted against foreign GDP, showing up as a negative increment to MFP growth), while at the same time the *marginal MFP contribution* in Europe is rising, suggesting (as confirmed by projections) that the rate of domestic exploitation of knowledge capital will pick up again after about 2017. As noted for the base case, the *contribution of physical capital* (e.g. communications networks) to MFP growth remains negative, falling sharply in response to the current recession before 'recovering' to resume its slow decline. Compared to the base case, however, the picture is a bit brighter; the productivity benefits of networks are lower in the Borderless World until 2019, but thereafter rise above the base case as Europe learns to exploit the new market environment. The main implications of this scenario are the increased importance of human capital (HC) and (eventually) physical capital (PC) and the waning (negative) contribution of knowledge capital (KC). The following figures show the different and shifting composition of MFP growth factors for EU27 (Figure 4) and the BRICs (Figure 5).

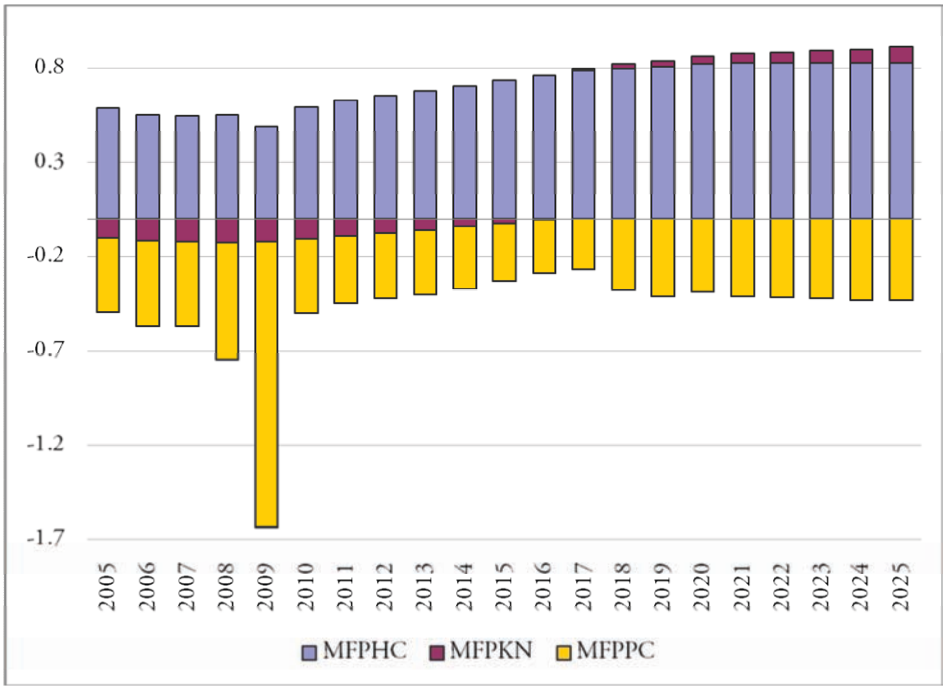

Figure 4: **MFP growth components, EU27, Borderless world**

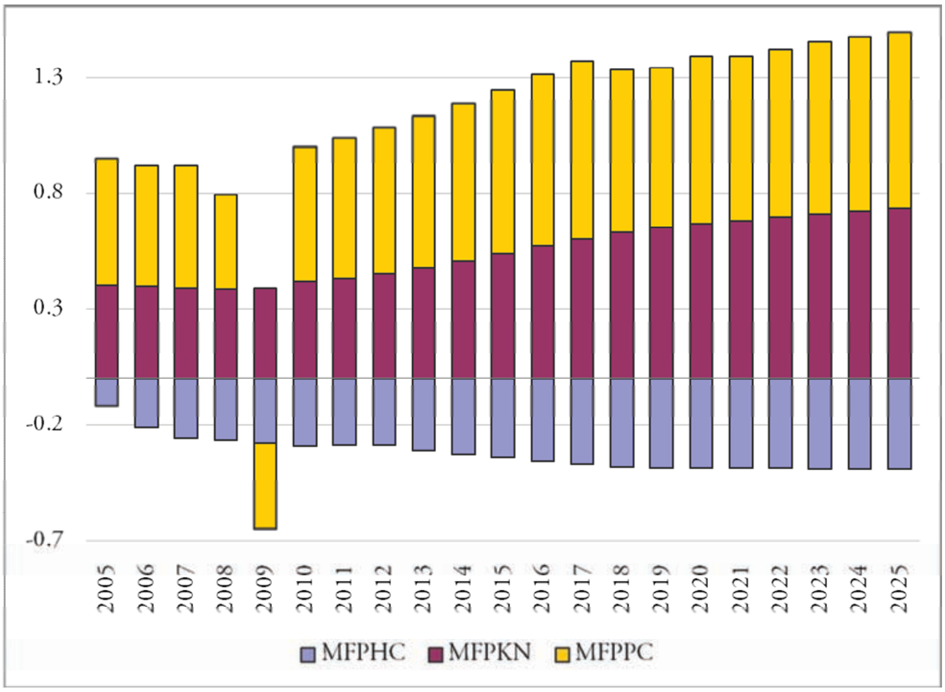

Figure 5: MFP growth components (HC, KC, PK), BRICs, Borderless world

Outputs

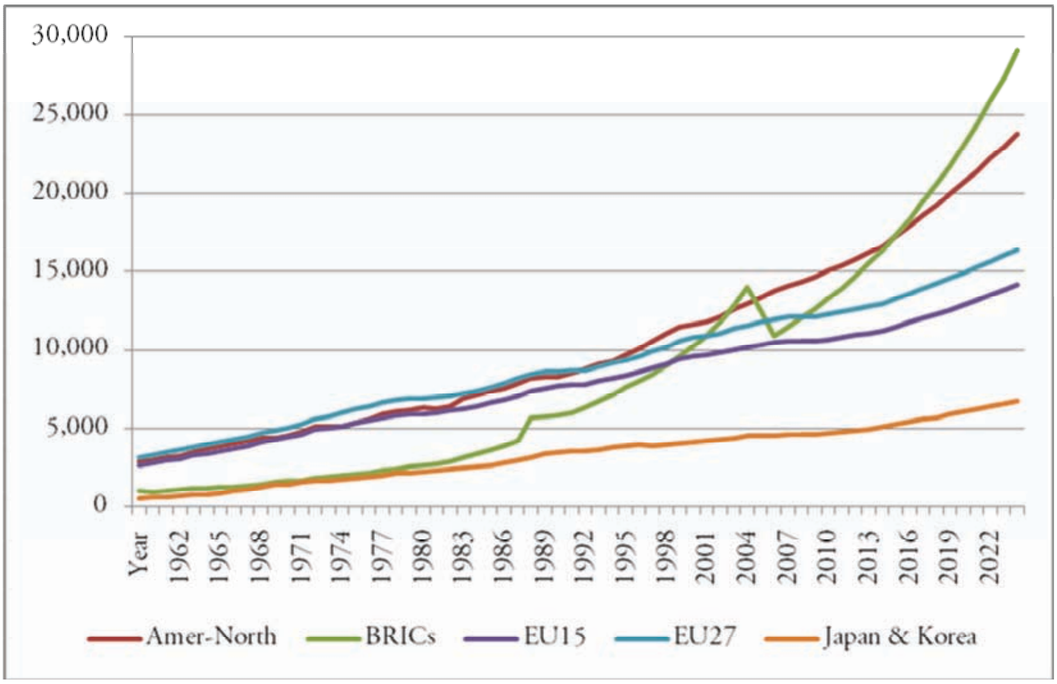

Figure 6: GDP at PPP with historic data (BW scenario)

GDP growth, as expected, is slower in this scenario, with the exception of the BRICs. Even there, the growth in paid-for output is very small and does not begin to compensate for the loss of production in the (currently) more developed aggregates, reflecting the shift to unpaid-for output. The picture remains the same in per capita terms and is confirmed by the GDP growth figures, except for a brief spike in Japan & Korea associated with the introduction of 4G mobile technologies such as LTE. The *prolongation of the current recession* can be seen in the following graph of the change (relative to base) in the growth rate of GDP for the main regional aggregates (Figure 7) and the comparison of the base rate and Borderless World GDP growth rates for EU15 and EU27 (Figure 8).

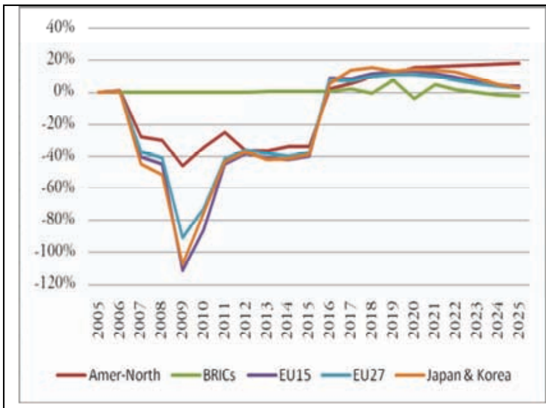

Figure 7: **Change in Borderless World GDP growth rate**

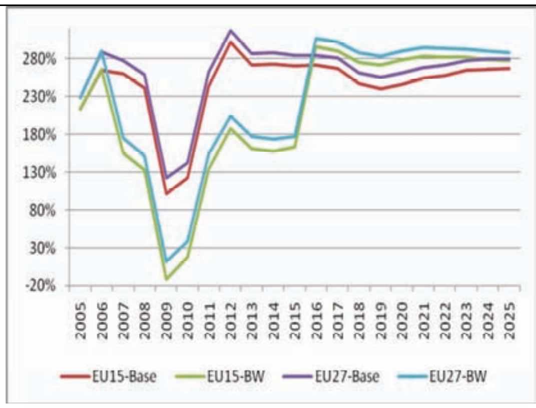

Figure 8: **EU GDP growth rate, base and Borderless World**

Inequality and power

Inequality does not change much in absolute terms in this scenario. It rises slightly in the BRICs, as a result of greater influence of global economic competitive forces, but declines slightly in the other regions, as global economic opportunity compensates for the saturation responsible for rising inequality after 2016 in the base case. This effect wears off as economic development levels out, and inequality begins to creep up in the more developed regions and to plateau in the emerging BRIC economies, as shown in Figure 9.

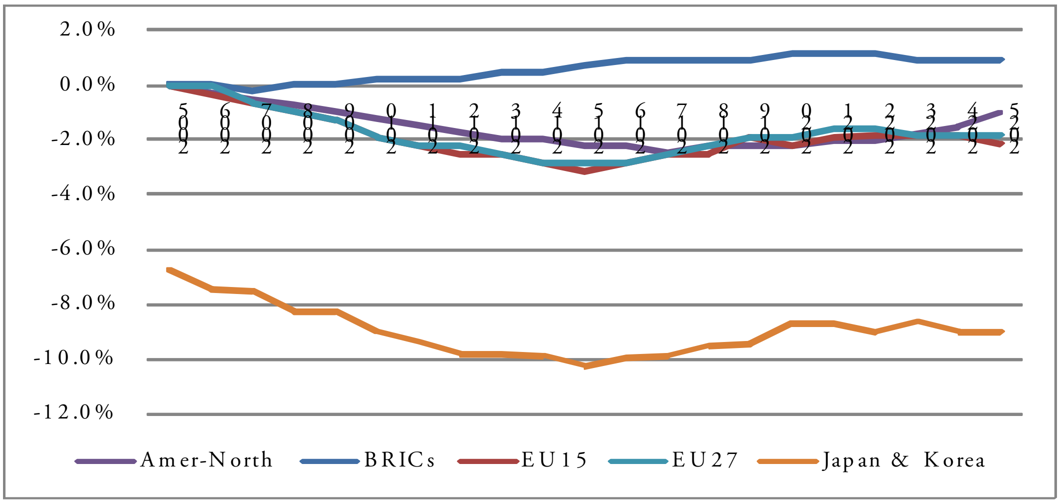

Figure 9: Changes in domestic inequality, Borderless World relative to base case

The Borderless World produces a further shift in global power from North America to the BRICs, but leaves the EU's decline untouched. Technology power growth in the BRICs reduces the power of the EU as well.

Connecting World

Framework conditions

The acceleration in EU *network infrastructure growth* noted above for the Borderless World is stronger in the more controlled (and publicly-governed) Connecting World (a 60% increase over the base case compared to 40% in the Borderless World). Growth in Japan & Korea is also accelerated, but this effect is very modest (maximum 10%) and disappears after 2019. By contrast, after a long period of adjustment (consolidation of market positions and overcoming government-reinforced barriers to participation) the BRICs experience accelerating growth after 2015. The importance of fixed-line infrastructures in the Connecting World and the greater emphasis on Universal Services (and on telephone infrastructures as means of delivering them) means that the Connecting World sees acceleration in *telephone infrastructures* throughout the world. This is fastest in the EU and Japan & Korea until 2018, but reverses thereafter. On the other hand, the BRICs (and to a far lesser extent North America) see *accelerating growth* throughout – in the former case as a direct result of general economic development and attendant public policy.

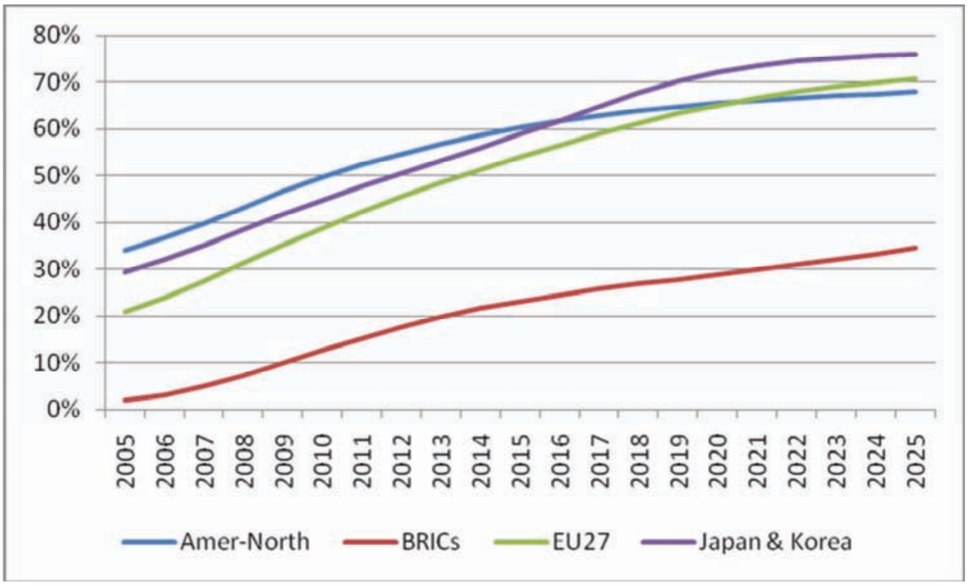

Figure 10: % of networked people (CW scenario)

Compared to the base case, the *growth in the % of networked persons* is also much faster in the EU and Japan & Korea until 2019. In Europe, the growth remains above the base case (indicating a higher level of saturation). In terms of *globalisation*, the picture is similar to the Borderless World; Europe continues to lead the way in taking advantage of the scenario's specific opportunities.

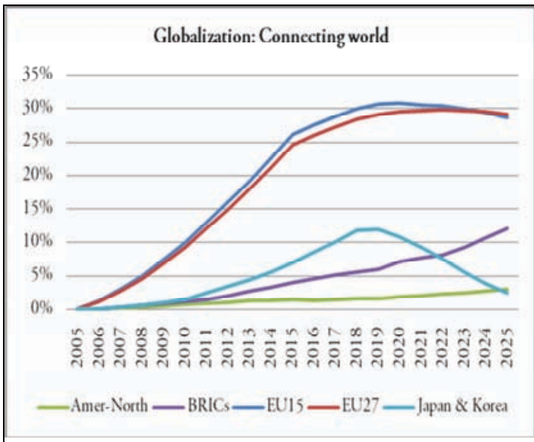

Figure 11: Globalisation, CW Scenario

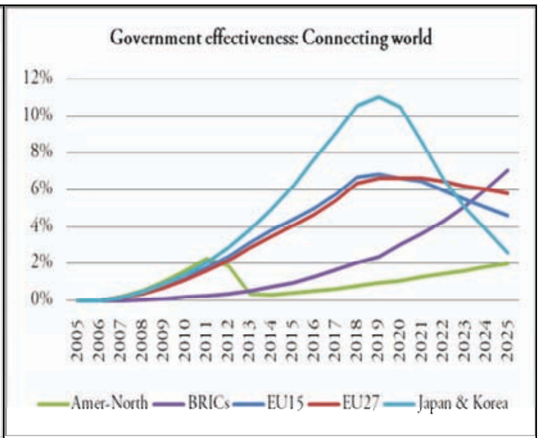

Figure 12: Government effectiveness, CW scenario

However, the combination of greater control over the returns to exploiting Europe's intangible assets and the greater influence of mediating public sector forces effectively doubles this effect; while globalisation (Figure 11) eventually rises 18% faster in the Borderless World (compared to base), the *sustained rate of additional growth* is around 30% in the Connecting World. The other regions also experience the benefits of greater overall economic activity, though again Japan & Korea peak around 2019 and fall back towards the base case growth (parallel to but lower than in the EU). *Government effectiveness* (Figure 12), as expected, is higher in this scenario, but reaches a peak (for the EU and Japan & Korea) by 2019 while accelerating in the BRICs. *The Knowledge Society index* also grows faster in this scenario than in any other, though the peak in 2019 in EU and Japan & Korea allows the BRICs to overtake them by about 2022. The major lesson is therefore that this scenario benefits infrastructure creation and globalisation and strongly favours the development of a global Information Economy in which Europe plays a leading role, but where the admission of the BRICs to the 'Top Table' eventually consolidates the shift of economic power.

Inputs

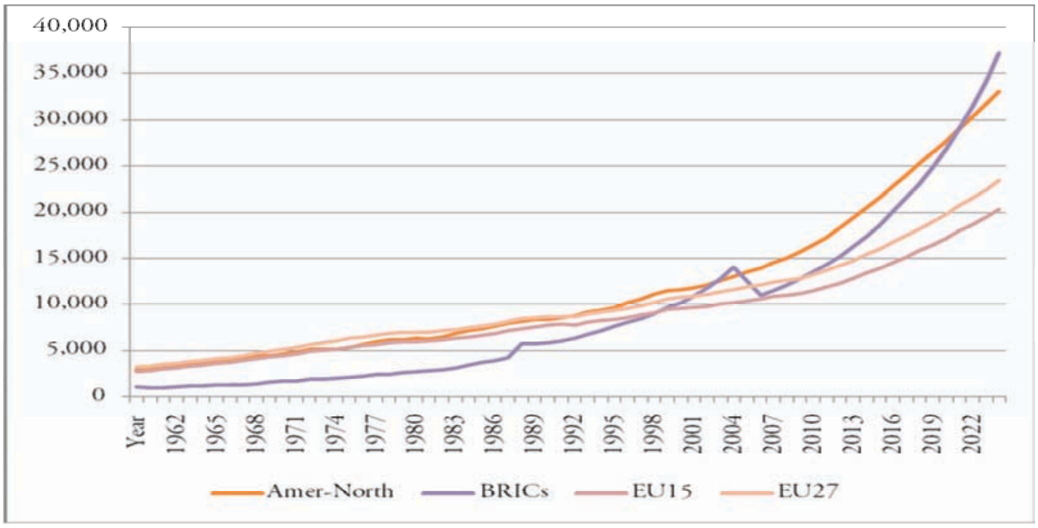

Figure 13: GDP at PPP $ with historic data (CW scenario)

This growth is not free; compared to the base case this scenario sees high and even accelerating growth in *government expenditures*. Interregional differences are modest, though the motivations and detailed breakdowns are different (see below). The impact on *private investment* (Figure 14) shows an even steeper proportionate decline, but this is entirely due to the much greater increase of GDP in this scenario relative to the level of investment required to sustain it. Thus, growth (at least in Europe) becomes increasingly capital-efficient. On the other hand, investment in the BRICs continues to outpace GDP growth, indicating that their real potential for economic dominance lies beyond 2025 and thus that Europe faces a long-term challenge in maintaining its strong position.

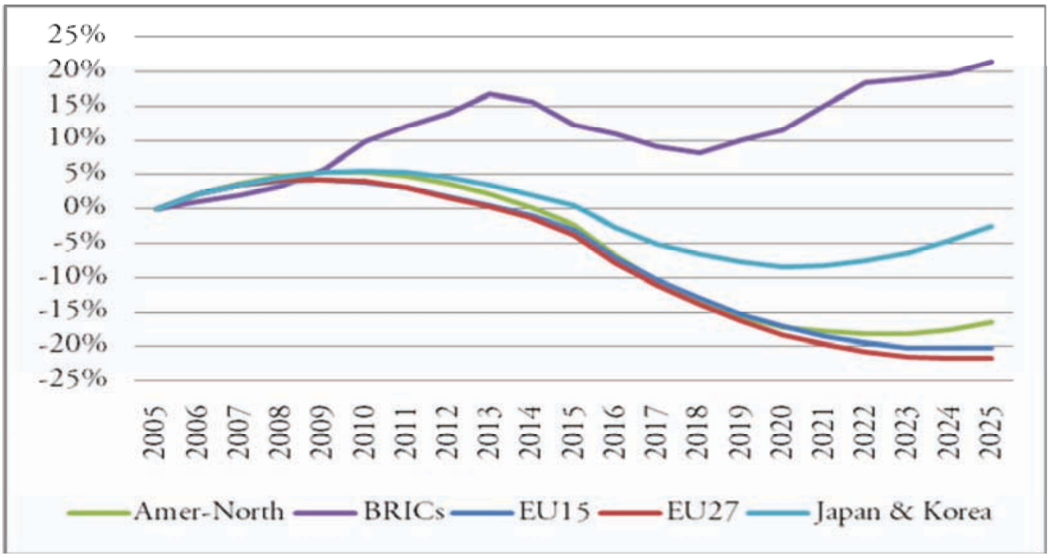

Figure 14: Change in investment as % GDP comparing CW scenario to base

Multifactor productivity

The *MFP growth* benefits of this scenario take the form of roughly parallel accelerations in the EU, Japan & Korea and North America, but these are largely exhausted by 2015, while the BRICs continue to benefit. In *human capital* terms, all regions enjoy a transitory increase in the productivity contribution of human capital to MFP growth, but this is really an acceleration of the rate of benefit rather than an increase in benefits; the excess contribution begins to reverse by 2018 for North America, 2019 for Japan & Korea and 2024 for the EU. The BRICs reap a sustained benefit, but this merely slows the erosion of the human capital contribution, which remains negative throughout. Compared to the base case, *Knowledge Capital* continues to make strong contributions throughout the period growing faster in the EU than in the BRICs. The contribution of *physical capital* is negative for most of the period (except as noted above for the BRICs), but this does turn around by 2022 for the EU15 and new generations of infrastructure-based technology come on-stream. The different regional composition of MFP growth is shown in Figure 15.

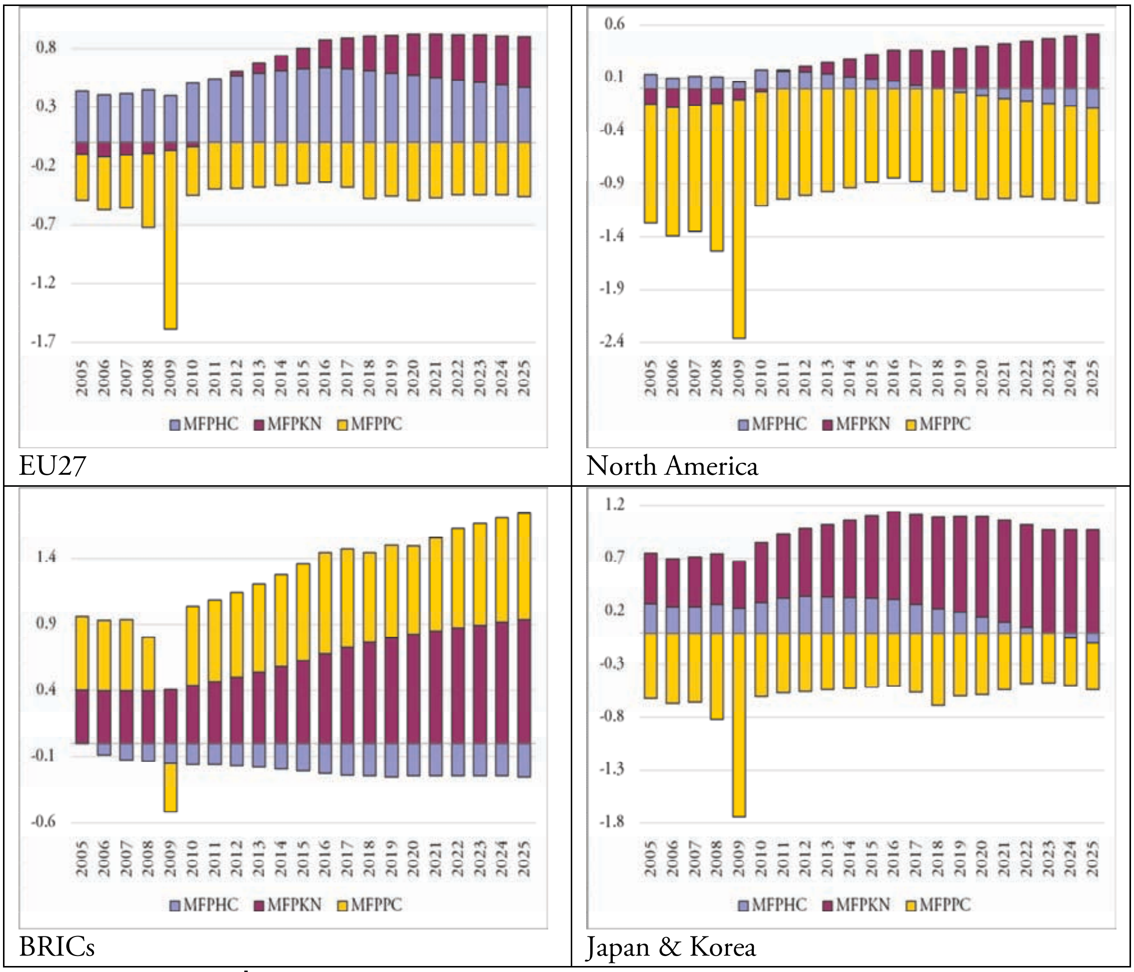

Figure 15: MFP growth composition, CW scenario

Outputs

The EU's developed market system and balanced public policies allow it to take advantage of this new environment in terms of economic output. In both aggregate and per-capita terms, it keeps pace with Japan & Korea and outpaces the lagging BRICs (held back by a weak initial position and high reinvestment rates) and North America (which begins to fade after 2020).

Inequality and power

The price for this economic success is *growing inequality*. Inequality grows throughout the world; until 2018 (when it is overtaken by North America), the EU leads this unedifying race. After 2020, however, the balance shifts and equality once more starts advancing in the EU. The gradual shift in power towards the BRICs is largely unaffected by scenario developments, but Europe's technology power rises rapidly compared to other regions, outstripped only by North America, with its more business-friendly public sector policies and extensive legacy IPR endowment.

Scattered World

Framework conditions

In the Scattered World, Europe strongly pursues investment in *network infrastructure*, while the rest of the world experiences slower growth. This reflects various factors; Europe's internal market growth and the two-way (protectionist) impact of policies and technological incompatibilities create the need and opportunity to complete the trans-European network infrastructure, creating a secure platform from which European goods and services can be rolled out to many sections of the world while at the same time protecting European industry and tax revenues from foreign penetration. In contrast, the BRICs, lacking the combination of market readiness and market access, do not have the same incentives. *Telephone infrastructures*, being associated with more localised activity, grow throughout the world (compared to the base case); in Japan & Korea and the BRICs they take the place of lost network infrastructure investment. Indeed, their 'excess' (relative to base) investment continues to accelerate in those regions, but is largely spent by 2019 n the EU. In this world, North America sees little external growth and its expenditures on both types of infrastructure are virtually flat; having developed its internal markets, there is little incentive for more than replacement investment. Growth in *network uptake* follows a pattern similar to that in the Connecting World, but at approximately 1/5 the level.

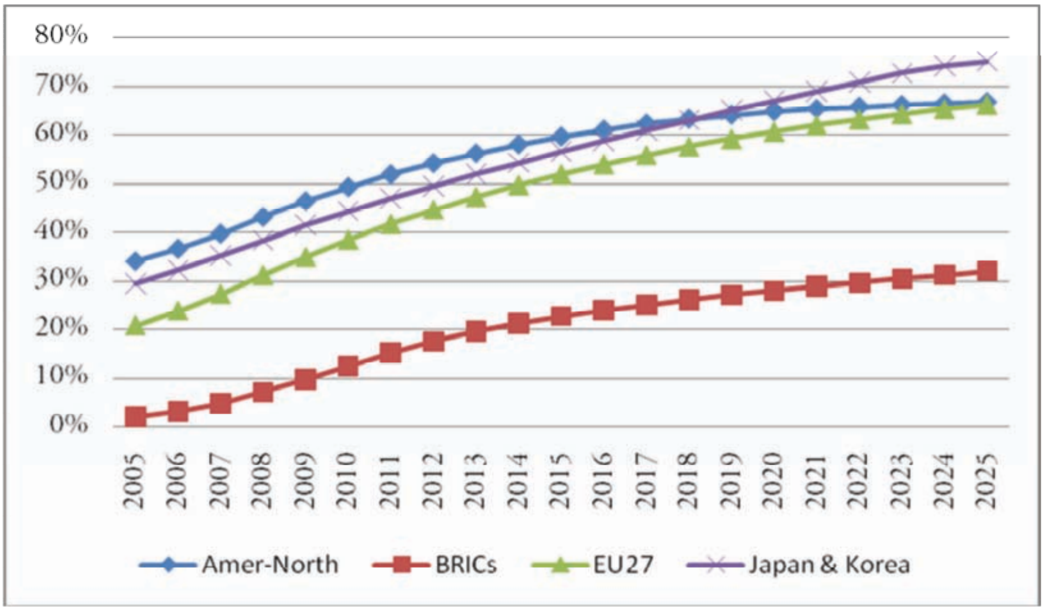

Figure 16: % of networked people (SW scenario)

Globalisation follows a pattern similar to that of network infrastructure; an acceleration in the EU (rising to 20% faster growth compared to the base case) and deceleration elsewhere (though less marked in the BRICs due to the competitiveness provided by lower labour costs and the progress of education, combined with the more rapid development characteristic of these emergent economies). *Government effectiveness* also increases (except in North America, where a brief stimulus associated with protectionist policies is spent by 2013), but this effect is far less prominent than in the Connecting World. *Knowledge Society Index* growth remains universally higher than in the base case (due to the stimulus associated with niche market development and the reinvestment of excess profits generated by local monopolies), but again this is slower than in the Connecting World. This attenuation is less in the BRICs, of course, due to the compensating stimulus provided by development of internal markets.

Inputs

Government expenditure is boosted in the EU by costs associated with e.g. unemployment; this effect is even stronger in North America. On the positive side of this scenario, the decline in EU *private investment* as % of GDP is almost completely eliminated by about 2015; because GDP is higher, private investment increases in absolute terms. Again, this greater willingness to invest is associated with the development of the Single Market and the relatively greater share of domestic demand accounted for by European firms, which more than compensates for loss of access to increasingly competitive global markets. Investment continues its decline in Japan & Korea and is almost flat in North America and the BRICs.

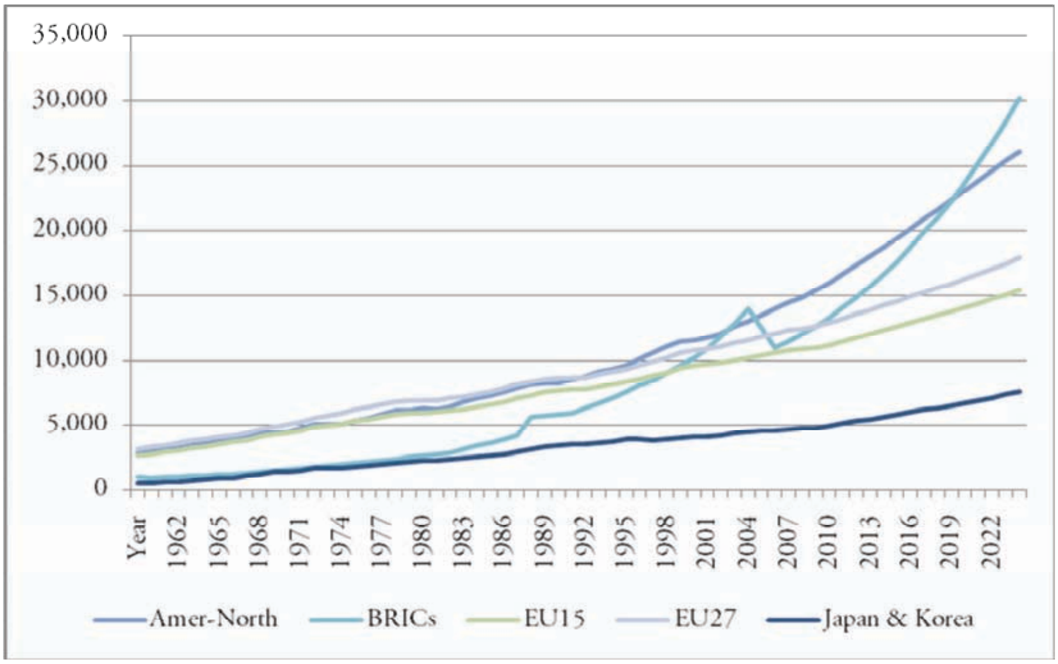

Figure 17: GDP at PPP ($Billion) with historic data (SW scenario)

Multifactor productivity

MFP is generally elevated in this scenario. Loss of European access to global markets brings saturation of *human capital* contributions (even rising unemployment); human capital acts as an brake on MFP growth everywhere except in Japan & Korea (after 2017) and the BRICs, who continue to benefit from low labour costs and complementary capital development throughout the period. Reduced access to content produces negative contributions from *knowledge capital* after 2010 – by 2015 this has spread to the BRICs; world productivity is more dependent on effort improvements and *physical capital* than on innovation and knowledge capital. This stagnation of the 'Knowledge economy' aspect is one of the chief effects of the monopolistic competition dynamic of this scenario – there remains a lot of innovation, but mostly 'mere variety' intended to reinforce market barriers and ultimately productive of neither welfare nor profit. Physical capital continues to contribute; this too can be understood in the increase of local over international economic activity, since the former is more dependent on the local enhancement of physical infrastructures.

Outputs

GDP does grow in the Scattered World compared to the base, but at only 10% the rate of the Connecting World. This attenuation is greater for regions with well-developed domestic markets than in, the BRICs, though in per-capita terms the BRICs continue to fall behind.

Inequality and power

Due to the above-mentioned computational anomaly, no clear conclusions can be drawn about *inequality* – the pattern broadly mimics that in the Connecting World, but this must be regarded as tentative at this stage. The *transfer of power* from North America to the BRICs is slightly accelerated in this scenario, but Europe's slow decline is unaffected. On the other hand, Europe's *technological power* does benefit from the increased protectionism and in particular from the chance to develop EU-specific technological assets.

3.1.4 Cross-scenario comparison of selected impacts

In this section, we present some cross-scenario comparisons for a limited set of key economic indicators, concentrating on EU27. In general, cross-scenario comparisons are discouraged, because they risk conflating very different causes and effects. However, these comparisons can be used to gain some insight into the relative importance of technological openness (comparing the Borderless and the Scattered Worlds) and of public sector governance (comparing the Borderless and the Connecting Worlds). This section also allows us to assess aspects of inequality that cannot be defined at the regional level: specifically the North-South divide and the global Gini coefficient.

Framework conditions

Table 5: Interscenario differences in the framework variables between 2009 and 2020

Framework variable\Scenario	Base	Borderless	Connecting	Scattered
Network infrastructure				
2009	34.9	41.8	42.1	41.9
2020	60.1	86.4	97.5	91.1
Telephone infrastructure				
2009	511.5	502.2	517.9	514.1
2020	638.9	599.6	722.9	649.5
Networked Proportion				
2009	34.9	34.8	35.1	35.0
2020	60.1	57.6	65.0	60.7
Globalisation				
2009	63.1	66.7	67.4	66.8
2020	80.0	93.3	103.7	96.3
Government effectiveness				
2009	3.9	3.8	3.9	3.9
2020	4.3	4.2	4.6	4.3
Knowledge Society Index				
2009	57.2	56.2	59.6	58.1
2020	66.1	63.3	78.4	71.3

These data show that both global reach and the ability to control exploitation are necessary for maximal infrastructure growth, and that telephony is of greater national than international importance. The uptake of networking is also highest in the Connecting World, but the importance of community ties and the intensity of use associated with trusted 'Walled Garden' environments show up in the strong performance of the Scattered World. Globalisation follows the combination of openness and public sector support. Interestingly, government effectiveness is also higher in the Connecting World; the greater 'traction' of the Scattered World cannot overcome the combination of capture by local monopoly power and reduced overall resources. In much the same way, the basic Knowledge Society index is maximised in the Connecting World, which facilitates a combination of public and private incentives for Internet development and exploitation.

Inputs and Productivity

Table 6: differences in inputs and productivity drivers between 2009 and 2020

Variable\Scenario	Base	Borderless	Connecting	Scattered
Government expenditure				
2009	3891	4108	3957	3866
2020	5532	6082	6821	5397
Private Investment as % of GDP				
2009	1.23	1.19	1.29	1.25
2020	1.07	0.97	0.88	1.17
Basic MFP growth (%)				
2009	3.16	3.11	3.54	3.22
2020	3.13	3.07	4.08	3.19
Human capital contribution to MFP growth				
2009	0.34	0.49	0.40	0.23
2020	0.49	0.82	0.58	0.44
Knowledge capital contribution to MFP growth				
2009	-0.15	-0.12	-0.07	-0.15
2020	-0.16	0.04	0.35	-0.24
Physical capital contribution to MFP growth				
2009	-1.50	-1.52	-1.52	-1.49
2020	-0.40	-0.39	-0.49	-0.39

- As expected (given the prominent role of the public sector) government expenditure is highest in the Connecting World. It is somewhat more surprising that expenditure in the Scattered World is lowest of all; this is due to a combination of weaker government revenues and a greater reliance on private sector provision of public goods. However, given the likely higher rates of unemployment, this probably means that GDP per capita understates the true social cost of the connectivity failure characterising this situation.

- In all scenarios, private sector investment falls as a proportion of GDP – however, this is generally due to the fact that growing productivity makes GDP rise faster than investment rather than being due to a fall in investment *levels*. For this reason, too, proportionate private investment is highest in the Scattered Worlds, because weaknesses in trade opportunities and protectionism hamper GDP growth and because retained earnings are dissipated in investment in ultimately self-defeating monopolistically competitive lock-in.

In terms of productivity, the shift of activity to the unpaid part of the economy combined with the growth in global (Borderless World) and local (Scattered World) monopolistic inefficiency account for the falling MFP in those scenarios.

- Human capital remains a net driver of productivity growth in all scenarios – this effect is strongest in the open exchanges and 'Web 2.0'-type innovation of the Borderless World, followed by the efficient organisation of invention in the Connecting World.

- Knowledge capital is currently a brake on MFP growth, meaning in rough terms that it attracts more payment than it deserves (possibly due to persistent market power in the control of intellectual property rights). This is reversed by 2020 in the borderless world and the Connecting World, where free access to ideas makes visible the potential return to their shared exploitation. It may seem odd that these returns are less in the Borderless World, but recall that these data measure only *monetised* returns and thus understate productivity gains in peer-based, open-source and other unpaid production.

- Finally, at a global level, the contribution of physical capital continues to be negative, although this is easing as new technologies reduce the deadweight loss of 'bottleneck' proprietary infrastructures (in all scenarios). In the Borderless and Connecting Worlds, this is a result of openness and shared use of Infrastructure Convergences; in the Scattered World it comes from technological limits to the exercise of local monopoly power.

Output, inequality and power

Table 7: Differences in output, inequality and power between 2009 and 2020

Variable\Scenario	Base	Borderless	Connecting	Scattered
GDP ($B)				
2009	10138	9825	10298	10206
2020	13514	12434	16636	13823
Per-capita GDP ($K)				
2009	24.98	24.41	25.31	25.12
2020	31	28.95	37.54	31.62
Domestic Gini				
2009	0.321	0.321	0.329	0.329
2020	0.319	0.311	0.34	0.34
Power				
2009	17.24	17.19	17.21	17.23
2020	14.41	14.24	14.55	14.31
Technology Power				
2009	310.1	296.2	318.4	313.4
2020	484.6	422.3	713.1	504.4

- The Connecting World shows the strongest output growth, as expected. The Scattered World edges the Borderless World because the local monopolies of the former tend to produce more revenues than the cutthroat competition in all but the infrastructure (and vertically foreclosed) parts of the Borderless World.

- The pattern recurs with per-capita GDP; all scenarios see increasing average wealth, but this is highest in the Connecting World, where greater control and pro-growth redistributive policies maximise the contributions of trade and technological advance.

- Average inequality is also higher in the Connecting and Scattered Worlds, as a consequence of 'tipping' in the former case and market power abuse combined with the impact of high unemployment in the latter.
- Finally, while governments in general are becoming less powerful (asymmetries of power among nations are weakening), technological power is increasing. In the Connecting World, this effect is strongest due to the concentration of 'linking power' associated with relatively 'scale-free' (concentrated) linkage patterns, while in the Scattered World it stems from control of key technologies that define 'interoperability zones' to which both customers and suppliers are locked-in.

Global inequality

The IFS model provides three indicators of global inequality: Gini coefficients for income inequality among nations[100] and among the world population and a 'North-South gap' GDP/capita ratio in the top 10% and the bottom 10% of nations, shown in Figure 18.

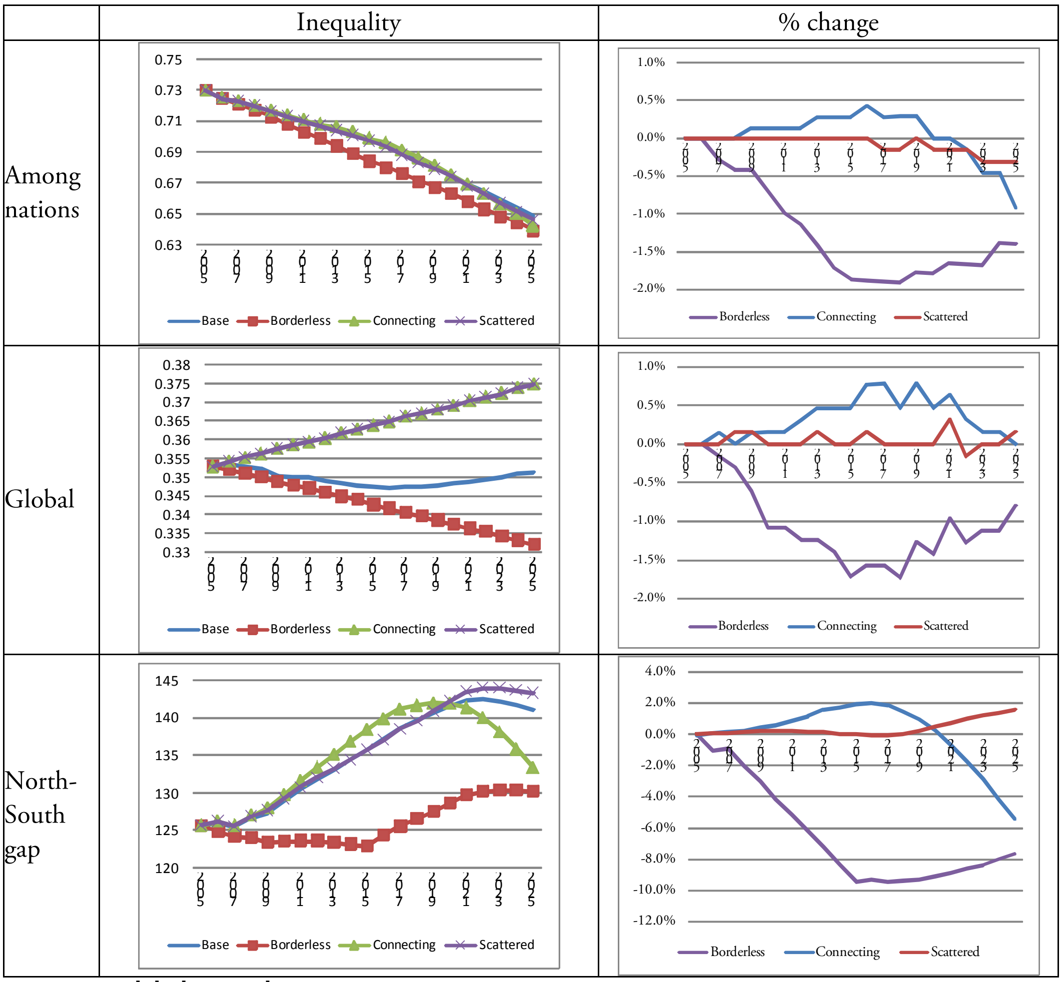

Figure 18: Global inequality

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[100] Computed from the income (GDP) distribution across nations (what % of world GDP is accounted for by the poorest x% of countries).

These data show that:

- All scenarios lead to a decrease in inequality between nations (top row). However, inequality between societal groups within nations increases in the Connecting and Scattered Worlds (middle row).
- Because the Gini coefficient only measures 'average inequality' it is also useful to consider the gap (in GDP/capita) terms between the richest and poorest deciles among nations (bottom row). In the base case, this grows appreciably until 2021 before declining slightly as the global economy matures. By contrast, in the Connecting World the gap peaks earlier (and at a lower level) and declines more steeply thereafter (due to reduced protectionism and the eventual maturation of the poorer economies); the same forces produce a later (higher) peak and a slower closing of the gap in the Scattered World. In the Borderless World, the gap closes slightly during the initial years (as the poorest nations gain some measure of market access) but the gap widens thereafter due to the 'tipping' tendency of the more developed nations to dominate global trade.
- Compared to the base case, the Borderless World is initially associated with faster decreases in inequality; this beneficial impact wears off as the 'Winner-takes-all' tendency of the global networked economy gradually concentrates market power.
- This effect is more pronounced for the global measure, which captures the growth of inequality within as well as among nations.
    - Borderless world: Development gap between rich and poor (North-South divide), initially decreases, as the poor nations harvest the low-hanging fruits of joining the global Internet economy and as key businesses migrate to lower-cost countries. This initial gain is not sustained, however; as market power consolidates and prices rise, the poorest nations again begin to fall behind.
    - Connecting World: Initial increase in inequality as those with control of key technologies consolidate their market power. Over time, however, redistributive and pro-trade public policies strongly reverse this. By the end of the forecast period, growth in equality is steeper in than in the Borderless World forecast, indicating that Connecting World will eventually be more sustainably equitable and thus, implicitly, endorsing the case for strong public sector engagement.
    - Scattered World: There is little evidence of sustained change from the base case in terms of inequality at the individual level, but some evidence of a convergence among nations. Significantly, however, this is not replicated in terms of the North-South gap, showing that the richest and poorest nations are moving farther apart[101].

3.2 Assessing Social Impacts

Compared to economic impacts, social impacts present a more complex challenge. They are inherently subjective and the most important elements are difficult to quantify, let alone

[101] This is consistent with the economic analysis of 'conditional convergence' in innovation and other developmental forces, which suggests that nations slightly behind the frontier accelerate towards the frontier, but nations below a critical level of development are progressively left behind.

model in numerical terms. Moreover, many of the most significant impacts occur as a result of 'weak signals' and are best discussed at a conceptual level. The social impact analysis strives for a holistic and integrative assessment based on a range of very different approaches that proceed from such different premises (e.g. the individual vs. the collective as a unit of analysis, rational choices vs. culturally ingrained behaviour, social structures defined in terms of groups vs. social networks, etc.) that they are difficult to unify in a meaningful way. Social impacts and reciprocal implications for technology trends were assessed by extrapolating existing evidence and theory on the social impacts of ICT -particularly network technologies – in the context of the specific scenarios and on making use of conceptual models developed in the peer-reviewed literature. Both the quantitative projections provided by the IFs system the sociological, economic and psychological theories used in the literature to project or give insight into societal impacts are used to provide context, calibration and colour, rather than precise predictions – indeed, it seems evident that they reflect either easy-to-measure variables or the very different premises of their disciplines and cannot be consistently combined.

In all scenarios, commercially motivated activity is central to the flow of innovation and to pricing, access, quality of service and other factors shaping the welfare productivity of GDP. Businesses will compete to obtain consumers and partners by offering better products on more attractive terms, but only to the extent that they appear better than rival offerings in attracting economically valuable users. Once they have been attracted, commercial firms will want to limit subsequent mobility by increasing switching costs. The scenario dimensions directly reflect the alignment between economic outcomes and welfare: openness reflects the ability to change (and thus whether variety truly reflects different needs); competition indicates the degree to which firms try to attract others' customers; and public sector dominance indicates whether regulation or compensatory policies are used to 'correct' asymmetries of power between firms and users (i.e. market failures).

Four main drivers were produced by modifying a framework developed by the Universities of Twente and Siegen[102]. This framework was chosen in order to promote overall consistency between the (past- and present-orientated) perspective of that study and the future-directed perspective of the scenarios in the current study. The initial formulation used the same drivers for the economic and societal impacts, but this tended to over-emphasise the role of markets and the reductionism of profit-maximisation, thereby missing much of the essential richness of the networked society. Indeed, just as the technological level of description found in e.g. technology foresight studies and the economic perspective taken in endogenous growth models provide detailed pictures of specific domains of development, the social impact analysis consciously strives for fidelity to social forces *per se*. This differentiation mirrors the formulation of policy as well: regulation, in particular, is fairly clearly divided between technical, economic and social regulation. While each type can be used to attain objectives from the other domains, this can only be accomplished if each domain is developed in a self-consistent fashion, engaging with the others on the basis of real-world developments and overarching strategic objectives. The drivers chosen for the social impacts analysis are:

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102 Input material for this section: Internal document SMART 2007/0068, courtesy of University of Twente and an outline by the Oxford Internet Institute.

(1) *Rationalisation,* which captures the individual understanding of options and activity and places the discussion on a continuum between choice and behaviour.

(2) *Social capital and networking,* which allows us to look at patterns of connection (structure, strength, direction and duration) and develops the context of individual behaviour and scope for collective action.

(3) *Empowerment and participation*, which looks how (in terms of opportunity and activity) individuals come to form or join effective (acting) groups and influence or implement group choices or behaviour. It connects individual choice to the social fabric and to collective action.

(4) *Information and lifelong learning*, which captures the process by which individuals and groups respond to perceptions of a changing world and the consequences of past choices. It connected the past to the future.

Table 8 scopes these by their mechanism, meaning, links and its impact per domain.

Table 8: Social impact themes

Theme	Mechanisms	Meaning	Links	Impacts per domain
Rationalisation	Individual choice	Individual understanding of options and activity (selecting options)	Continuum between choice and behaviour	Consumption; Innovation
Social capital and networking	Social interaction	Patterns of connection (structure, strength, direction, duration)	Context of individual behaviour and the scope for collective action	Family, Community Structures; Health
Empowerment and participation	Participation and engagement	How (opportunity and activity) individuals come to form or join effective (acting) groups and influence or implement group choices or behaviour	Connects individual choice to social fabric and collective action	Participation in Policy Making
Information and lifelong learning	Learning	The process by which individuals and groups respond to perceptions of a changing world and the consequences of past choices.	Connects past to future	Education; Work

These drivers reflect different 'levels' of interactivity that lie behind the impacts of the Future Internet. In other words, the impacts of technology-triggered development will depend on the collective and cumulative behavioural response of individuals. This, in turn rests on the way individuals make decisions, the influence of social groups in framing those decisions, the forces that trigger conscious decisions as opposed to unconsidered or routine behaviour (participation or engagement) and the dynamic stability of these trends – e.g. the degree to which the human system learns about the impacts as they unfold and adapts, thus closing the loop to future technology development. From this perspective, rationalisation refers to the quality of individual decision making – in essence whether individuals can make informed and appropriate choices among the alternatives available. Social capital refers to the unstructured, self-organising or emergent mechanism through which individual actions tend to produce systemic impacts – this draws attention to both the overall "wisdom of crowds" and the importance of *structures* of social interaction (not simply how many or which kind of people interact, but who interacts with whom). Empowerment refers to the participation of individuals in group structures – both formal groups (i.e. the extent o which connectivity-based policy can rely on public participation) and informal structures (i.e. the dynamics and generative qualities of existing social structures). Finally, lifelong learning gives explicit recognition to the fact that the networks of individuals and organisations are overlaid by networks of communication and learning – that innovation, for instance, involves both the creation and the diffusion of knowledge. Therefore, these four drivers provide the essential building blocks for a linkage between the social forces underpinning the Future Internet and the (technical, economic and societal) benefits expected to flow from it, since these benefits are all produced by human interactions.

The drivers also serve to classify impacts, which are considered in relation to market outcomes. Projected future social impacts are summarised in the following sections.

3.2.1 **Driver 1 Rationalisation: choice, values, creation; consumption:**

Information technologies are expected to support a trend of rationalisation. However, not all tech trends point in the same direction and there are variations among scenarios. The concept captures individuals' levels of understanding and ability to make rational decisions. It is interpreted here to include 'professionalisation', creation, innovation and the ability to make choices, including choices about consumption.

Rationalisation links to professionalisation and to a drive for effectiveness and efficiency. The retrospective analysis identified a trend towards professionalisation, which is likely to affect society in various ways, including increased reliance on expert professionals and the increased injection - even into non-business decisions – of business-derived methods, approaches, technologies and instruments. All such tools and processes embed assumptions both about how individuals will use them and about how they relate to each other. The growing spread and use of professional tools in private life is likely to reinforce the blurring of private and professional spheres.[103] To the extent that it accurately describes the current situation, this 'rationalising trend' may therefore reinforce the tendency to view social evolution as the collective expression of individual optimisation[104] and the dominant or

[103] van Dijk (2007) further develops this theme and considers the fading away of boundaries between the macro-, meso- and micro-levels of social life, between the public and the private sphere and between the spheres of living, working, studying, recreation and travelling as one of network society's most important characteristics,

[104] As noted, optimisation is meaningless without 'of what?' and as normally applied is a tautology –preferences cannot be observed, so we assume that people intend (or choose) to do what they are seen to do – their preferences are whatever is maximised by their observed behaviour. Note, too that (economic) approaches outside this individual choice frame (esp. behavioural and macro economics) retain their potency as ways to analyse socio-technical evolution despite not being explicitly based in optimisation.

default way to predict and rationalise human reactions to changing technologies and other factors.

Under all scenarios Europe (EU-27) is most likely to lead the continuing trend towards secular rational values, followed by the BRICs and North America. Secular-rational values seem to be most embedded in a future based on strong public governance, open technologies and collaborative market structures. The figure below projects the development of rational values for the three scenarios across America, EU 27 and the BRICs, based on the UN Human Capital Index[105].

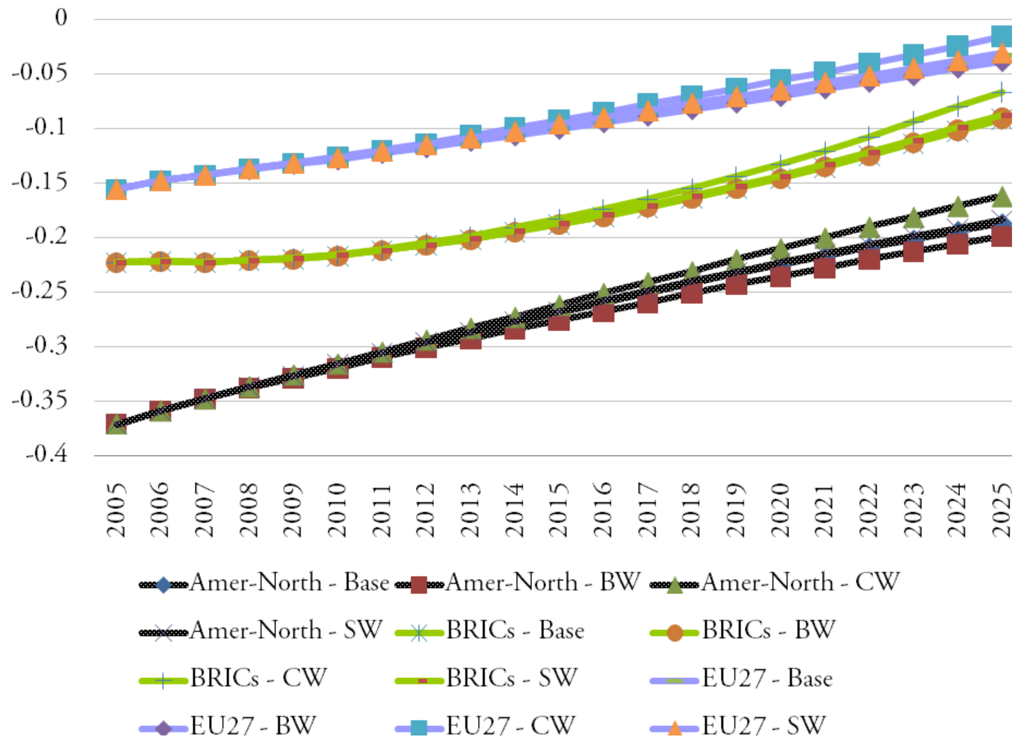

Figure 19: Global trend from traditional towards secular-rational values

Figure 19 compares the development of traditional versus secular rational values across three regions (EU-27, BRICS and North America) and across scenario worlds[106]. Questions about faith, abortion, sense of national pride and respect for authority define whether a person is considered to be traditional or secular rational (scaling: -2 for traditional and +2 for secular rational). Figure 13 shows that Europe (EU-27) is most likely to lead a global trend towards secular rational values, followed by the BRIC countries (Brazil, Russia, India and China) and NA. It also shows that the rise in secular-rational values seems to be most embedded in the Connecting World

The ability to make informed choices is taken as an indicator of welfare. Whereas in general it is assumed that ICT increases choice, there is a notable difference between tech trends.

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[105] See http://www2.unpan.org/egovkb/egovernment_overview/humancapital.htm

[106] Indicator has been taken from the World Value Survey and modelled within IFs.

Utility Computing and Infrastructure Convergence make rational decisions easier by facilitating access to information. Human-computer Convergence and the Intelligent Web may have the opposite effect, making the system more important than the individual by considerably increasing the complexity of options among which the individual has to choose or by pre-empting at network level discretionary decisions once the domain of individuals.

The neoclassical model[107] is predicated on extensive rationality. The increasing complexity of the Internet world sets natural limits on the extent to which individual rational choice and associated social evolution leads to welfare improvement. The projection in Figure 20 demonstrates that there is hardly any correlation between connectivity and rationality. This lack of correlation underlines the mixed impact the technology trends have on the way people inform themselves and how decisions are made.

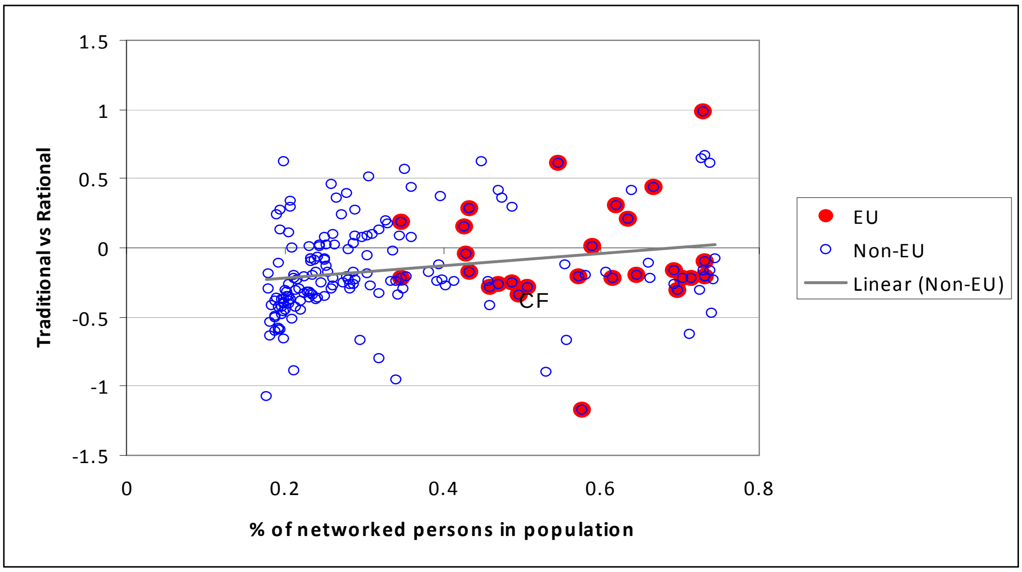

Figure 20: Correlation between rational values and % of networked persons

Source: RAND Europe

The use of rationality as the central metaphor rests on its accuracy[108] to some degree and on the availability of alternatives, e.g. *bounded rationality, which* is more realistic than 'pure' rationality but less arbitrary than 'pure' behaviourism – in which people's behaviour is not clearly linked to decision and choice.[109] As a way of coping with complexity people simplify choices or limit optimisation to the identification of a 'good enough' option[110]. Such *satisficing behaviour* may lead to distinctly second-best outcomes, especially when scaled up

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[107] For a discussion and critique, see e.g. Simon (2000).

[108] Accuracy in the sense that it describes both a tendency of individuals to make choices that further their objectives and as a summary of the 'evolutionary' optimum seeking behaviour of markets and other groups. For a critical evaluation of the evolutionary and rational explanations of economic behaviour, see Hodgson (1994).

[109] Key references: Simon (1955), Mouzas et al (2007).

[110] Simon introduced the concept of 'satisficing' in his earlier writings (Simon 1955).

to the aggregate level. It may, for example, lead to loss of variety, where we each end up free-riding on the most popular preferences? If so, would the impact be a useful compromise (minimising supply-side costs of 'versioning' and demand-side costs of identifying an 'optimum' that may be only slightly better than the 'second-best' choice[111]) or haphazard or lowest-common-denominator approach that satisfies no-one? In the different scenarios, this leads to difference in the way that globalisation will lead to global monopoly, enhanced global competition or the survival of niche players offering a rich diversity of products.

The vast range of information also holds the promise of relaxing one of the main threats to economic, socio-political and environmental sustainability: the *fallacy of monotonicity*. Traditionally, policy (in the commercial as well as the public sphere) has tended to divide things into 'goods' and 'bads' and to assert that more of the former (and less of the latter) always represents improvement. The world created by the Internet of X challenges this in several ways. In particular, more information does not always lead to better decisions and more interactions do not always lead to more meaningful interactions or greater control. At a more profound level, the growth imperative that has driven our economy is beginning to appear neither necessary (with the increasing importance of non-profit or self-motivated productive and innovative activity) nor always desirable (as cooperation outperforms competition in some domains and as the risk consequences of growth maximisation become more evident). Finally, the importance of distributions of connectivity, societal costs and benefits and control are increasingly evident, calling into question the wisdom of striving to maximise the amount of intangibles like trust and security[112]. This general modification of the 'more is better' principle may lead to a stabilisation of growth paths, a reduction in the more destructive forms of competition and perhaps even to a more sustainable concept of welfare satiation in place of continual improvement (for some).

Another way individuals cope with a complex world is through the use of agents or intermediaries. After the initial 'disintermediation' as online search crowded out brokerage services, the growing complexity of online information is provoking the emergence of new forms of (often benevolent) intermediation. These can amplify some of the benefits by facilitating information retrieval and help people to manage complexity and thereby ensuring higher and more equitable welfare. The effect is to change the direction of another driver; social capital (see Section 3.2.2 below). Social capital is often divided into three types: bonding (strong ties among similar people), bridging (weak ties among similar but distant people and groups) and linking (weak ties among different and distant people).

[111] The possibility that search and other optimisation costs outweigh the benefits is not arbitrary; suppliers will rationally invest in increasing search costs simply to lock-in consumers. Once sunk, the search costs of looking for a better option cannot be recovered if the result is disappointing, which in turn reinforces reluctance to search or experiment. Additionally, the collection of information about complex choices carries the risk of dissatisfaction with the eventual choice. On this last point, see e.g. Huffman and Kahn (1998) or Hanoch and Rice (2006).

[112] The point here is that the quality and distribution of e.g. trust and more security are more important than the amount. For instance, individual initiative may outperform trust in (especially dominant) intermediaries or agents. Similarly, security in depth (including at the end-user 'edges' of the Internet may be a necessary complement to security embedded in trusted systems at the centre, especially if perceptions of and dependence on security lead individuals to abandon risky innovation or excessively increase their sensitivity to any breach.

Overall technological intermediation and 'virtualisation' are expected to loosen social ties; in particular by strengthening bridging and linking over bonding social capital. However, if intermediaries get 'bottleneck' power because people cannot or will not bypass them, the opposite may occur. The 'hard' market power of service or communications intermediaries supported by concrete (technical or legal) barriers to entry is a recognised regulatory issue. 'Soft' market power based on reputational dominance, especially by intermediaries, is far less recognised and – accordingly – is growing faster as can be seen in the growth of reputation based systems for travel, to retailers, informal (e.g. eBay) transactions, etc. Beyond the economic implications of intermediation, recent trends indicate that individuals are consulting intermediaries for an ever-wider range of decisions, even to the extent of 'outsourcing their lives[113].'

Consumption patterns, the diversity of products, and the way they compete vary across scenarios. Openness and private sector dominance are likely drivers of mass customisation (more, but less profound variety). Brands become increasingly important as signals of expected quality; possibly leading to global market capture by a few big retailers and auction sites. Without effective competition or policy coordination, the benefits of global scale, open standards, rapid change and other characteristics of Internet-led development are unlikely to be sustained. In this setting, public sector activity is needed to protect user/consumer interests. This can be done through regulation, direct support measures or demand aggregation (e.g. procurement) – possibly coordinated on a global (market) scale.

Applying rationalisation, innovation and consumption to the scenarios

This section outlines the driver 'rationalisation', as pictured in each of the scenario worlds. For each scenario we briefly state the state what the driver is likely to bring about, and then the likely impacts on people. The influence of rationalisation on scenario development is especially marked in relation to two domains of human activity that define how and what people choose; creation and distributed innovation, which define the emergence of new options, and the supply of (especially paid-for) goods services and experiences, which determines which of the existing range of options are actually salient to individual choices[114].

Creation and distributed innovation:

- In the Borderless World, creation and innovation in network industries are likely to be dominated by a small number of large firms intent on exploiting innovation, hence producing low diversity. Such big players will wish to minimise the uptake of new, competing products and will therefore seek to create large switching costs for consumers.

Likely outcomes experienced by people: innovation is likely to be infrequent, disruptive, industry driven and characterised by tipping (reinforcing the dominance of large incumbents or triggering their replacement by new dominant firms rather than competitors). Markets

[113] See e.g. www.quintessentially.com

[114] Both are relevant to individual choices, because behaviour depends not only on what options are available, but also on what characteristics of those options are noticed and valued by individuals. As a result, the mere existence or likely future emergence of alternatives may discourage consumption of even the best available option; the formal analysis of innovation dynamics takes into explicit account the extent to which "the best is the enemy of the good." See e.g. the discussion of "excess inertia" in Katz and Shapiro (1985).

will therefore evolve in a punctuated[115] way, with long periods of trivial and localised change interspersed with brief episodes of revolutionary changes that promise large, visible and wide-spread benefits. Also, access to ideas may be unequally distributed: intermediaries at the focal points of innovation and market networks are likely to have more power and to be more exposed to new ideas than those at the periphery. If the market mainly allows for disruptive innovation, large multinationals will try to avoid disruptions to preserve market dominance, hence have a strong incentive to buy off small innovative SMEs and those that may become a threat, at an early stage. Innovation is likely to be proprietary and locked within companies, standards may not be consumer-friendly. Bottom-up innovation and Web 2.0 have less of a landing place and low public dominance means that there is no government to scream to.

- In the Connecting World, the speed of innovation is likely to be limited by the natural pace of government. Government ensures availability of funding is leading and setting the rules of the game and firms are likely to compete on merits.

Likely outcomes experienced by people: Innovation is likely to be bottom-up, evolutionary combinatory and user-driven. It is likely to embrace concepts such as crowd sourcing and the role of the prosumer, and hence blur the boundaries between producers and consumers. It may result in a larger variety of innovative, more suitable and user-friendly products and service; more diversity is clearly welfare increasing. Ecosystems are likely to drive innovation, embedded in flat and merit-based hierarchies that are flexible and changing. Propensity to copy is high and increases tipping, making markets more versatile.

- In the Scattered World innovation will be local and likely to be less innovative. Innovation is likely to follow a linear model of innovation, i.e. driven by producers as opposed to end-users.

Likely outcomes experienced by people: Innovation will have a strong local character and likely not to be interoperable. Innovation capacity is limited and may lead to many separated islands. Because transaction costs among islands are high (no standards, no interoperability) islands are likely to diverge. Socio-political structures are more likely to be hierarchical and layered; only permitting innovation that pleases the interest of the elite, likely not to show bottom-up innovation.

Supply of consumption goods (including media and entertainment, services and paid-for experiences) may play out differently in each of the scenario worlds.

- In the Borderless World, 'think global and sell global' will guide investment decisions that are likely to lead to one big player where everybody shops. Quality of Service is likely to be ensured by the product or service provider who will ensure that QoS is equal between players). A CNN type information model is likely to inform citizens.

Likely outcomes experienced by people: Dominance of large players will considerably limit choices and inhibit high switching costs in network industries. Mass-customisation with lots of trivial differences may produce an unimportant variety of products (variety is so

[115] This phenomenon was observed in terms of technological evolution by e.g. Arthur (1983). The punctuated evolution of firms in technologically dynamic markets, however, had perhaps its first comprehensive analysis in Schumpeter (1934).

interoperable that it is without profit), except for some cases where there is a dominant standard. Being global in scope, limitless choices in life-style products and services will make the need for brands and intermediaries most important in this world. Intermediaries are likely to create/impose structures and to build specialised worlds around them.

- In the Connecting world we may see a trend towards different and specific shops, all connected to global standards. An active role of government is likely to ensure the development of similar and comparable standards defining Quality of Service, objectivity, quality and equal access to information. A RSS-style information model is likely to inform citizens.

Likely outcomes experienced by people: markets are characterised by monopolistic competitive markets[116] giving more choices to consumers at competitive prices. The power of intermediaries is strongest in this World. Standards are likely to be open and develop bottom up, and more likely to be user-friendly. Governments will ensure harmonisation among standards & interoperability and promote consumption behaviour that aims to maximise social value.

- The Scattered World will see the development of regional shops that are not necessarily connected to each other. Market mediation will be high and likely to create regional restrictions and artificial scarcity (e.g. regional DVD coding). In terms of Quality of Service, this world is likely to see the development of different standards, having the effect that consumer may not share the same experience.

Likely outcomes experienced by people: many closed-up regional markets develop offering limited choices to local consumers, it is likely that different solutions (operating systems, software, etc) develop that are not compatible or transferrable to other regions creating large transaction costs across different worlds.

3.2.2 Driver 2 Social capital and networking – how people interact, family, community and care

At the individual level, social capital refers to the network an individual belongs to. The network provides value by giving access to others and facilitating exchange of information, enforcement of contract and focusing on a shared vision and collective goals (Nahapiet and Goshal, 1998). At the aggregate level, social capital refers to the social structure that affects the level of democracy and economic growth (Fukuyama, 1995; Putnam, 1995, 2000; Beugelsdijk and Smulders, 2003).

The Internet of X is expected to substantially increase connectivity of people to people, people to institutions, machines to people, things to machines, etc. This can be observed across all scenarios, however patterns of connection (structure, strength, direction and duration) may vary, defining different contexts of individual behaviour and the scope for collective action. As noted above, it is conventional to distinguish three types of social

[116] Monopolistically competitive markets share the following characteristics: (1) there are many consumers and few producers who do not control market prices; (2) consumers perceive non-price differences among competitors' products; (3) there are few barriers to entry and exit, (4) producers have some influence over price.

capital: bonding (strong ties among similar people), bridging (weak ties among similar but distant people and groups) and linking (weak ties among different and distant people[117]).

Openness, mobility and global connectivity are likely to weaken social ties and bonding social capital, but strengthen bridging social capital. This is conducive to innovation and growth, but weakens cohesion. Tools and behaviour developed in and for "fun "social networking - supporting bridging social capital - are increasingly applied in professional settings for improving productivity (e.g. crowd sourcing[118]). This emphasis on extensive weak ties is also correlated with the shift to secular-rational values, while traditional values are associated with bonding social capital[119]. This variation thus impacts family and community structures, but also the way social services like healthcare are administered.

Healthcare access, effectiveness of delivery and quality depend on organisation of the healthcare system. Depending on government intervention, social capital considerations can lead either to greater variation in service access and quality or more inclusive – and homogeneous - healthcare provision[120]. Either way, the future will see Internet based services, supported by Utility Computing and Human-computer Convergence and secured by the Intelligent Web in ways that can empower patients and increase the efficiency with which healthcare providers can deliver and monitor care. The result can be improved health outcomes leading to enhanced quality of life in terms of labour productivity and active and independent aging.

Technology trends, particularly Utility Computing and Infrastructure Convergence promote ubiquitous connectivity, enabling continuous communication and interaction. This allows individuals to influence large groups, with consequences that are difficult to apprehend, let alone control. The often disproportionate, unperceived or accidental importance of the individual is part of the emergent complexity that makes consideration of networking absolutely central.

Applying the social networking and capital to the scenarios

This section outlines the driver 'social capital and networking', as pictured in each of the scenario worlds. For each scenario we briefly state the state that the driver is likely to bring about, and then the likely impacts on people: Social interaction requires us to discuss impacts on family structures and community building as well as health:

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[117] Granovetter (1973) drew attention to the different productivity of these types of social capital in terms of innovation, noting that linking social capital was likely to prove most conducive to valuable innovation.

[118] For more detailed consideration of social business models, see the next section of this chapter.

[119] In welfare terms, bonding social capital is conducive to trust, while bridging social capital is better for resolving divergent objectives.

[120] Both have advantages in terms of scale economies and support by specific technologies, but reflect different types of social preference; at a simple level, variety is consistent with efficiency and homogeneity with equity. However, in mixed public-private systems, this argument can be reversed; variety may be haphazard and inefficiently aligned more with income or education than with need, while one-size-fits-all homogeneity may be both inequitable (treating in the same way those with different needs) and efficient (encouraging those with greater need to seek alternative (e.g. private) forms of care. eHealth technologies, especially those providing connectivity and information intermediation, can help to reconcile efficiency and equity.

Community and family pictured in each scenario world:

- In the Borderless World, high mobility is likely to lessen the importance of the family and of traditional community structures[121]. The importance of many weak ties defines social capital as 'bridging'; i.e. weak ties of similar but distant people. Yet, low public sector dominance may increase the importance of new types of communities and rely on the family to support mobility and to provide a 'safety net' (see Putnam's thesis of social decapitalisation).[122]

Likely outcomes experienced by people: Social structures are not attracting a lot of identification and depth, hence all ties become weak and the serendipity of link formation is likely to considerably increase tipping and make the network more instable.

- In the Connecting World, high mobility and high dominance of public sector is likely to lessen the importance of the family in providing a 'safety net' for its citizens. Government may provide family support programmes, bringing families closer to each other.

Likely outcomes experienced by people: likely to favour development of Web2.0 tools that lead to high economic growth and productivity: Connecting World seems to strive the best balance between strong and weak ties. It encourages the formation and use of many weak ties that are likely to foster innovation (leading to more numerous and diverse ties). Governments have an incentive to invest into bridging social capital; i.e. creating weak ties of similar but distant people is empirically good for growth.

- In the Scattered world mobility is likely to be lower. Family is likely to be closer and dominates social life and interactions.

Likely outcomes experienced by people: low economic growth and low productivity; attaching a large importance to family ties as opposed to encouraging the development of secular-rational values is negatively related to economic growth (see empirical results as presented by Beugelsdijk and Smulders (2003).

Health:

- In the Borderless World and in the Scattered World, an incidence care model is likely to develop, supported by a large variety of commercially supported self-diagnostic tools, serving as a front end of a commercial clinic.

Likely outcomes experienced by people: high inequalities in access and quality of service between low and high income groups. (survival of the fittest and richest)

- In the Connecting World, a total care model is likely to develop, supported by a set of self-diagnostic tools that are provided as part of the system. Holistic and preventive

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[121] The scholarly literature on mobility in relation to both telecommunications and urbanisations suggests that the formation of strong ties relies on durable social contact and important shared interests among people with relatively few opportunities to substitute other connections when difficulties are experienced. A shared history of 'hard times' can provide a reference point to prevent fragmentation in the face of future shocks. See e.g. van Dijk (2006), Castells (2004) and Wittel (2001).

[122] Putnam 2000.

medicine tools are provided by patient associations and government systems and integrated in the healthcare system.

Likely outcomes experienced by people: equality in access and quality of service, better health and affordable medicine for all are likely to increase life expectancy and quality of life.

3.2.3 **Driver 3 Empowerment and participation - why people choose or act**

This driver considers how (in terms of opportunity and activity) individuals form or join effective groups and influence or implement group choices. This connects rationalisation to social fabric and collective action. Impacts include whether technology trends provide more, better, less risky and/or more understandable choices.

We may expect Utility Computing and Infrastructure Convergence to facilitate eDemocracy and eGovernment. Utility Computing will provide massive storage and smart indexing systems that enhance access to public information. Embedded in Intelligent Web functions that necessary security and transparency), it can deliver new services and discourse possibilities, both permitting and motivating greater citizen engagement.

New forms of Internet connectedness (e.g. social networking sites like Twitter) are fundamentally changing concepts of identification and identity management. Memory will be continuous and pervasive. But if memory is identity, changes in stored data change our effective identities, making them at once more plastic and shared to a greater extent with others. These hybrid identities involve humans with machines, humans with humans and machines with machines. New connections also serve to enhance cognitive processes.

However, many commentators and analysts also see rebound effects, from the death of privacy to a weakening of moral responsibility. According to this perspective, an effective system of self-control relies on a combination of awareness of externalities, understanding of the mechanisms linking acts and consequences, an ability to affect these consequences in a meaningful way and an individualised 'moral sense.' If people lose the power to perceive, understand or control their impacts on others[123], or if they come to rely on automatic systems or public scrutiny to justify actions or prevent 'bad' choices, they are less likely to take responsibility. Empowerment and responsibility can also be unequally distributed by e.g. unequal access to education and (e)skills or to networks themselves. Especially as technologies provide more potent and complex scope for 'user control', this empowers small elites but disempowers much larger groups. Empowerment may also bring a duty to be involved, whilst real empowerment would imply the freedom to opt in and opt out[124]. Formalised empowerment may also limit incidental connections and the serendipitous benefits of weak ties and of accidental participation.

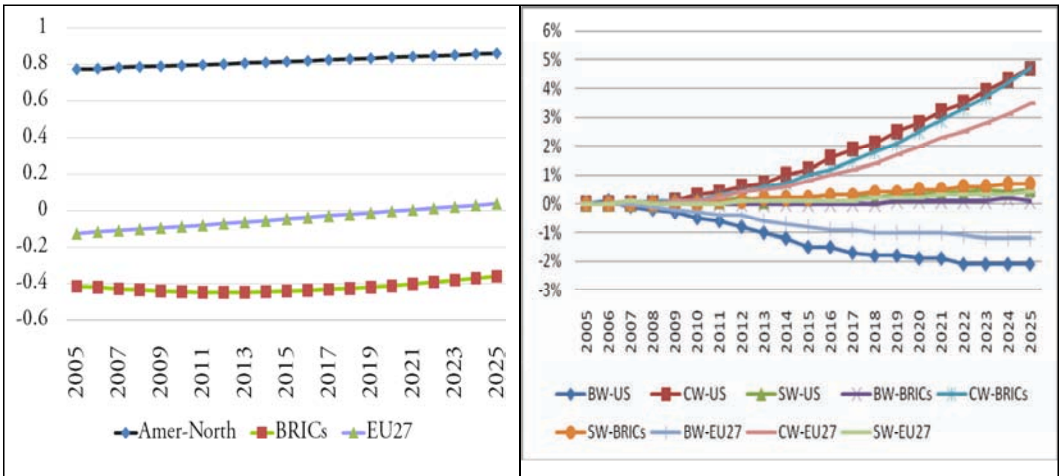
All scenarios make more tools available for influencing and participating in public decision making. However, impact requires people to recognise not only social networking tools, but

[123] These losses may be the direct result of increasing complexity, which floods individuals with information about increasingly global or 'emergent' impacts that can be linked to their own actions, but not in ways that can be described at the individual level. See e.g. Bedau and Humphries (2007).

[124] The distinction between actions driven by duty and those motivated by expected consequences is central to modern ethics and thus to the philosophical analysis of the Internet Society. See e.g. Coyne and Wiszniewski (2000) and Castells (1996).

also institutions whose policies they can influence and incentives to engage seriously. Weak public governance can thus reduce empowerment, if a liberal tendency to open up public decision making gives way to a laissez-faire abdication of responsibility or is seen to disguise a hidden agenda of covert control. However, too much government may equally stifle the bottom up dynamics of empowered citizens and groups.

More generally, this exposes the *fallacy of aggregation*; in a less-connected world, it was conventional to believe that large groups of rational individuals would interact to behave like an equally rational 'representative agent' pursuing consistent 'compromise[125]' interests. In addition, it was believed that individuals were relatively powerless to effect change; some form of 'critical mass' being both necessary and sufficient. In the worlds generated by the technology trends considered here, none of this necessarily holds true. The collective system may not behave according to any consistent rationale; alternatively, it may be more rational than individuals, especially in coping with patterns of change too complex to be apprehended by any single person or small group (including political elites). Set against this 'wisdom of crowds' are equally striking examples of individuals (or small innovations) that have produced profound impacts, while at the same time large-scale collective determination (e.g. to 'deal with' emergent global problems) seems in too many cases unable to produce effective change.



Base Case	Changes from base case

Figure 21: Self-expression by region

The welfare consequences of the Internet also depend on the progression from fear (survival) to hope (self-expression) as a driving force. The latter is likely to grow in all scenarios, with a general picture in which North America starts off predominantly governed by self-expression and becomes increasingly so; Europe starts off predominantly orientated towards survival but has become self-expressive by now and the BRICs are survival-orientated throughout, though after 2014 they tend to become more self-expressive.

Stronger differences occur across scenarios: in Asia and North America, the trend towards self-expression (driven by per-capita GDP) is strongest in the in a world of public governance. Europe sees an early threat from North America and Asia, but becomes more

[125] The compromise ranges from (money-weighted) averages (economic) to median preferences (political).

optimistic as it consolidates its ability to exploit its intangible human and social capital. However globalised competition could lead to a reversal of this trend. By contrast, the BRICs show the reverse pattern; they retreat strongly under public governance and stay essentially constant where the growth in global trade is just balanced by shrinking profit margins and population growth.

Applying empowerment and participation to the scenarios:

This section outlines the driver 'empowerment and participation in policy making', as pictured in each of the scenario worlds. For each scenario we briefly state the state that the driver is likely to bring about, and then the likely impacts on people:

- Resulting from the low dominance of the public sector, the Borderless World is likely to see the lowest level of participation in policy making. However there is a lot of private initiative, which blurs the boundaries between the public and private domain. *Likely outcomes experienced by people: policy making and co-regulation may primarily be driven by the people directly affected (citizens give a mandate to the government, industry will give a mandate to the government), it may be the case that government dominance is so low that government becomes irrelevant in some domains.*
- Resulting from the high dominance of the public sector, the Connecting World is likely to see the highest level of participation in policy making. Depending on the culture and intention, we can picture two extremes: (1) government may show an interest to share power with citizens and encourage/empower citizen to participate in policy making and to allow for bottom-up policy making; or (2) government may decide to keep power, pursuing top-down policy making. *Likely outcomes experienced by people: tech trends are likely to support effective policy making, bringing citizens and government closer to each other and increasing direct impacts of policy making. eDemocracy and eGovernment tools are likely to develop, creating a platform for bottom-up engagement with government, encouraging policy making to be more driven by citizens and hence more likely to respond to direct needs of citizens. NGOs are likely to form thematic clusters and to collaborate in order to get global leverage.*
- Low dominance of the public sector will play out differently in the Scattered World. Levels of participation in policy making most likely differ per Scattered World. *Likely outcomes experienced by people: power patterns are unlikely to change (those in power are likely to get more power). Yet, a strong civil society activism may develop as people unhappy with a particular issue are less likely to leave their world and hence more likely to defend their ideas. Institutions and organisations are likely to drive activism and movements.*

3.2.4 Driver 4 Information and lifelong learning- working, learning, and how people improve

This driver captures individual and group responses to knowledge of the past and expectations of future change. ICTs facilitate access to and new forms of information and learning (in particular lifelong learning) but they also require continuous skill updating and information processing, making them increasingly essential to social life.

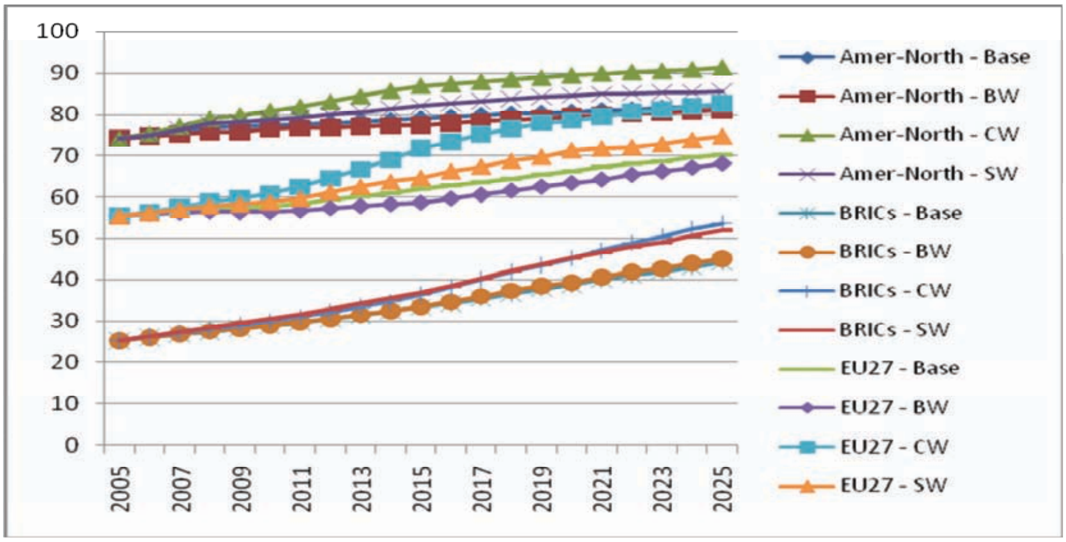


Figure 22: Developments in the Knowledge Society Index

The Knowledge Society Index is calculated as the sum of research and development expenditure and growth rate of tertiary education (Graduate rate relative to intake rate and population percentage). It serves us as a proxy for lifelong learning. Figure 20 compares the development of the Knowledge Society Index across the three regions (EU-27, BRICS, and North America) and across scenario worlds. The Knowledge Society Index is likely to be highest in North America, followed by EU-27 and BRICS. The Connecting World seems to be most favorable in driving forward the knowledge society – statement holds true across regions

Human Computer convergence and the Intelligent Web are likely to move key decisions into the network itself. Access to these technologies will be intuitive and require limited technical expertise, creating increased demand for soft skills. Human-computer Convergence, Utility Computing and the Intelligent Web will run on network structures and offer new linkages. This will make how and what we communicate and learn more individualised. It will also dramatically change research and education infrastructures, requiring new ways to monitor and promote quality[126]. However, research also underscores that soft skills don't replace hard skills; it's critical to have science/engineering competence as well to make good decisions about how to develop and deploy tech-based resources.[127]

Increased mobility and global connectivity are likely to spur the battle for talent. The confluence of private sector objectives and open technology should produce a global convergence of education content. Education is likely to become a critical national as well as personal asset if the job market of the future is as global as the flow of goods and services; leading possibly to commercial elite institutions providing 'branded' education and increased inequality of access and skills[128]. Public education dynamics depend on whether government

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[126] See European Commission (2009).

[127] Bikson *et. al.* (2008)..

[128] Note that unlike income inequality, which can promote or retard growth, educational inequality always slows GDP growth. See e.g. Lim and Tang (2008).

success in promoting the European Research Area[129] can be extended to induce students to benefit from the rich supply of education across Europe through common standards and joint educational programmes. Without such rationalisation there may be over-supply of education without sufficient variation. Alternatively, national competition may produce isolated centres of excellence, under-exploitation of the potential synergies across Europe and lost economies of scale.

To improve labour mobility, governments are expected to expand cross-border services. Where private sector influence is strongest out-migration of workers (or in-migration of work) is likely to increase. Where governments obstruct this trend, we are likely to observe the reverse; brain drains and outsourcing of skilled work that reduce the social returns to education and possibly displacement of businesses to where labour is more readily available. Unemployment will be higher and more structural due to lack of flexibility in the labour markets. Work and careers will develop (at the higher skill levels, at least) a portfolio character. Large global companies will invest more in attracting than in retaining talent and skills. A by-product will be the emergence of online (public and private) services to enable workers to manage their own training and social security across Europe and possibly globally.

3.2.5 Associating Tech trends with prospective social impacts

In the sections above the social impacts were associated with drivers in the context of the scenarios. For the purpose of this study the link should be made between the tech trends, drivers and impacts across the scenarios.

Thus questions arise how tech trends will lead to more choice, better choices, or more welfare-enhancing behaviour and to greater or lesser importance for individual decisions as compared to system or collective decisions; or how will they be impacting on social capital and networking, as well as the individual capability to participate. The approach taken has allowed us to further refine and focus the prospective description of tech trends and their associated social impacts.

- *Increased individual decision making power*: Utility Computing and Infrastructure Convergence: will make rational decisions at the individual level easier by facilitating access to information
- *Increased complexity*: Human-computer Convergence and the Intelligent Web are likely to make the system more important. Human-computer Convergence is expected to increase the complexity of options among which the individual has to choose. It may produce new ecosystems and trigger discussions on ethical and psychological level, ultimately questioning the effectiveness of individuals and linkages at affective level; the Intelligent Web will embed in the network itself many discretionary decisions once that were once the domain of individuals. Eventually, the intelligent web is likely to reduce the scope and meaning of individual decisions.
- *More connection, better access*: The development of a common communications infrastructure will help to rewire the future network, removing some sources of

[129] European Commission (2009).

exclusion and discrimination, providing greater ease of access. Thus, the supporting technologies 'draw in' new people and uses and put them in greater touch with one another.

- *Societal transformation:* The ubiquity of Utility Computing (i.e. putting computing on the same footing as water, power and telecommunications) demonstrates the degree to which 'merely quantitative' advances on processing, storage, etc. develop qualitative transforming power precisely by being interconnected through the network.
- *Changing geometries of power*: The progress of Human-computer Convergence can make the 'ends' of the network smarter (e.g. through enhanced decision support), thus changing the need for active traffic monitoring and management in the network itself and the resulting geometries of power and control. On the other hand, the electronic enhancement of human experience (e.g. via new input and output interfaces, etc.) creates a potential need for social connection – in the same way as advances in stand-alone platform-based computer games laid the foundations for today's on-line gaming and associated social networks.
- *Supporting innovation*: Similarly to the computing as utility cluster - the deployment of existing technologies providing 'intelligence' to the protocols, structures and internal functions of the Internet itself rebalances responsibilities and contributions of different stakeholders to overall socioeconomic impacts and creates a powerful 'pull' factor for further technological, economic, financial and social innovation.

We conclude the social impact analysis with the following statements (per theme):

Rationalisation: whether, how and what people chose

- *Looming sustainable welfare:* Looking for 'good enough' solutions will help decision makers to cope with the vast amount of information that they are expected to process. It may lead to some inertia that slows down innovation but may also encourage people to jump too soon into fancy new things that do not necessarily work out the way they hoped. Over time, this may relax the 'more is better' notion driving perpetual growth and lead to more sustainable welfare satiation.
- *Rise of the Intermediary*: Benevolent intermediaries can absorb some of the benefits. They may facilitate information retrieval and help people reduce the complexity of the world to something more manageable; hence play an important role in ensuring a more equal distribution of benefits and lead to higher welfare. However, caution is required if intermediaries get 'bottleneck' power because people cannot or will not bypass them, which may cause inefficiencies.
- *Blurring of private-professional spheres*: Tech trends are likely to further blur the distinction between private and professional spheres.

Social capital and networking: how people interact:

- *Bonding, bridging, and linking*[130] *social ties:* Weak ties matter as much as – and for some purposes more than – strong ones[131], so a scenario that encourages the formation and use of many weak ties may be more innovative than one that facilitates strong (and therefore less numerous and diverse) ties. Investing in bridging social capital, i.e. creating weak ties of similar but distant people is empirically good for growth. Attaching a large importance to family ties as opposed to encouraging the development of secular-rational values is negatively related to growth.

Empowerment and participation: why people choose or act

- *Increased individual engagement*: Tech trends such as Utility Computing and Infrastructure Convergence are likely to give more weight to and facilitate eDemocracy and eGovernment. It may offer a platform for bottom-up engagement with government and encourage policy making to be more driven by citizens and hence more likely to respond to direct needs of citizens; increase effectiveness of policy making.

Information and lifelong learning: how people improve

- *Importance of 'soft-skills'*: Soft skills will become even more important than hard skills. Tech trends such as Human-computer Convergence and the Intelligent Web are likely to move decision making power from the end points to the network. Interfaces are likely to be intuitive and easy and may require limited technical expertise. The centrality of collaborative behaviour is likely to drive demand for soft skills and to become central focus in education.
- Groups who learn differently will judge and work differently. Tech trends are likely to push the time-space distinction to its limits and increase attractiveness of teleworking.

3.3 Assessing Impacts on Business models

This section reviews a third category of impacts related to the two previous ones - economic and social impacts. It addresses the possible effects of the tech trends in different scenarios on current and future business models. First a brief overview is given of known impacts that the Internet and connectivity technologies have had on business. Then we review more explicitly how the tech trends might impact business models and vice versa in their ability to create and/or capture (public and commercial) value.

3.3.1 Internet uptake and use

The Internet has become an indispensible business tool with high penetration and use, though business process and CRM uses dominate on-line sales. The increasing salience of the online world and the key role of commercial activity in providing and populating it with opportunities make the Internet an important tool for business. As shown in Figure 23,

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[130] The most common distinction in discussing social capital is between bridging, bonding and linking. Putnam suggests that bonding social capital is good for "getting by" and bridging is crucial for "getting ahead" (Putnam 2000). Linking social capital refers to relations between individuals and groups in different social strata in a hierarchy where power, social status and wealth are accessed by different groups (Cote and Healy 2001).

[131] Granovetter (1973)

more than 90% of EU-27 enterprises have access to the Internet – even trailing EU Member States have high and growing levels of penetration (Bulgaria: c80% and Romania: c70%).

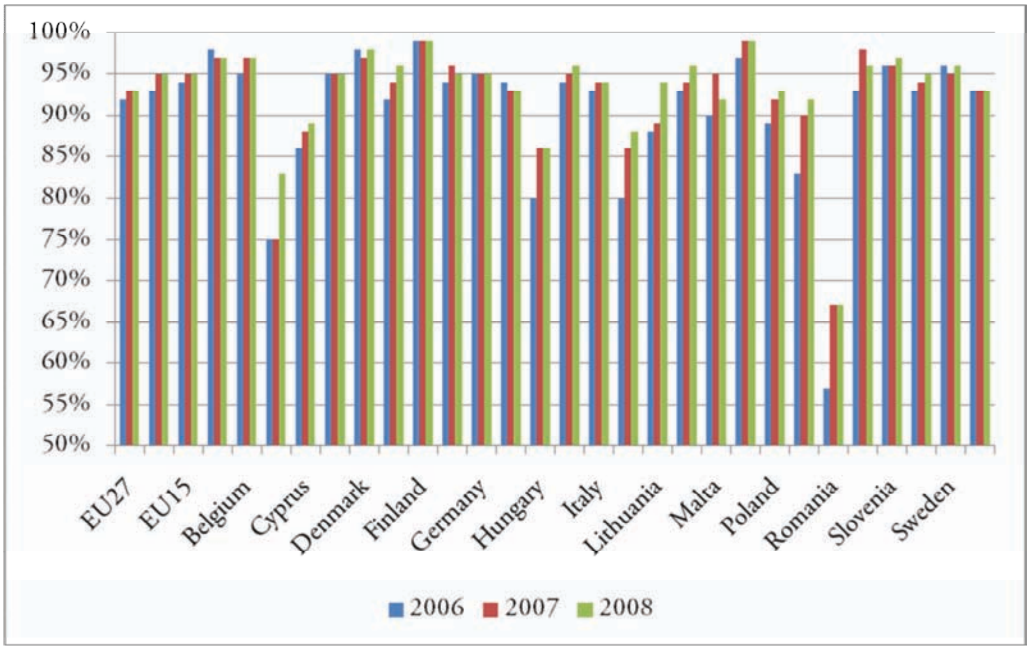

Figure 23: Enterprises (10 or more employees) with Internet Access

These data do not fully characterise Internet use *for* business. Figure 24 shows the proportion of total turnover derived from Internet eCommerce.[132]

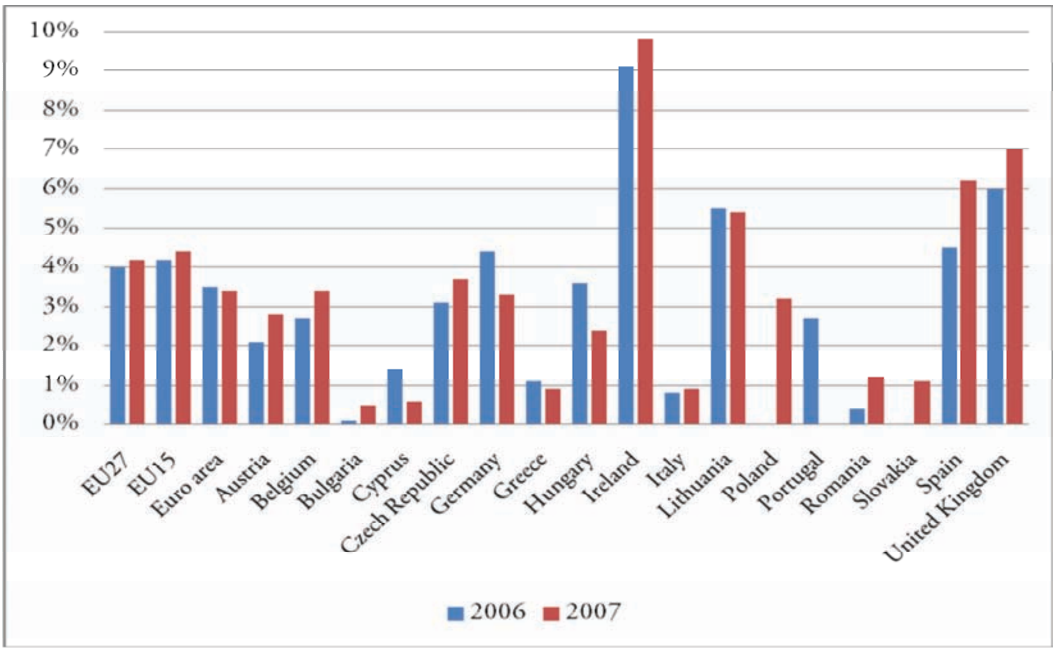

Figure 24: Internet eCommerce

[132] Source: Eurostat. Information comes from National Statistical Institute surveys on enterprise ICT use. Sales through other networks (e.g. EDI) are not included and only enterprises with 10 or more employees are covered.

These data show a mixed picture without apparent trends or patterns. The EU-27 as a whole obtained just over 4% of turnover in 2007, but few countries exceed 6% and Ireland top 8%. The reader should note that data are absent for many countries where higher figures are expected (e.g. Luxembourg and the Netherlands).

Business use of the Internet for activity *other* than buying and selling products or services has steadily increased. Figure 25 shows the increasing tendency to use Internet access for after-sales services (e.g. helpdesks)[133], reflecting the growth of extended, customer-centred business models based on more on *access* than sales[134].

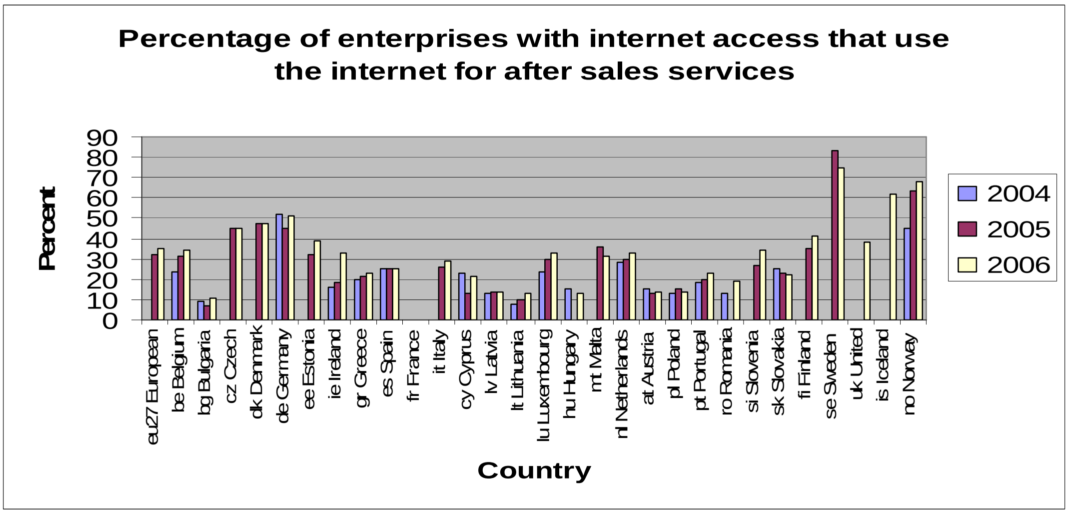

Figure 25: Internet Use - After Sales Services

Similarly, despite significant country level differences, a high portion of enterprises use the Internet for banking and financial services – in e.g. Denmark, Estonia or Lithuania rates hit almost 100%.[135]

3.3.2 **Internet impact of profitability**

Internet deployment has certainly challenged the profitability of traditional business models (OECD, 2006). The question is whether the Internet leads to more or less effective competition and whether that is a good thing. Falling entry barriers and expanding geographic markets have been seen as favouring more and fiercer global competition. On the other hand, scale, interoperability and network effects combined with the globalisation implicit in many new technologies to create more effective platforms for exercise of market power in some sectors, increasing the attractiveness of restrictive practices and creating market failure. Finally, some positive aspects of economic development may not survive globalisation; problems noted in the globalisation literature include variety, returns used to

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[133] Source: Eurostat

[134] Rifkin (2001).

[135] Source: Eurostat

support innovation, systemic risk, survival of smaller firms and the 'embeddedness' and stability of local economic returns.

Pervasive connectivity technologies also drive the exploitation of 'platform power' and the economics of lock-in. The result is a tendency for businesses to emphasise building and defending 'central' positions in preference to head-to-head competition with rivals or changes designed to distinguish the offerings of the enterprise from those of rivals. Much of the economic value created in Internet marketplaces by matching demand with supply - derives from standards for technology platforms and protocols for connecting and exchanging information. Once these standards are put in place, the added value of the marketplace is limited.

Dominance by global business brings certain benefits, such as economies of scale, branding and integrated service offerings based on proprietary standards. Under different market conditions, this can produce either 'intensive' competition (striving to produce faster, cheaper and better versions of similar and/or interoperable goods and services) or 'extensive' competition (striving to capture rival firms' offerings and to retain installed base by producing incompatible products in order to limit customer mobility). Intensive competition is associated with many of the anticipated benefits of 'good' connectivity and interoperability both in terms of innovation within technological paradigms and by lowering barriers to customers and to those new entrants willing to licence the dominant technology and join an 'interoperability cluster[136].' Too much intensive competition may inhibit the emergence of disruptive paradigm-shifting innovations; too little may threaten diversity and competition due to technological lock-in and rent seeking behaviour.

3.3.3 Business models interacting with tech trends

The reciprocal influences between tech trends and business model evolution can be assessed by relating the intention of commercial enterprises to capture value to the socially-beneficial by-product of value creation. Value can be created by process efficiency improvements or product service improvements arising from endogenous (within the firm and its formal partners) and exogenous (outside the firm, and often informal) innovation. Beyond this, value capture can be accomplished by lock-in and clustering.

Table 9: Examples of Mechanism to Extract Economic value

Mechanism	Description	Example
Online sales	use the large, captive user base to market own or third party products. Micro pricing: selling of unbundled low-value items as separate units using micropayment methods.	[Cyworld]
Advertising-based models	Models based on advertising enable users and hosts to preserve access to the content that is free of charge while bringing in revenue.	[Sueddeutsche.de]
Pay-per-click	site that pays affiliates for a user click-through.	[Rentability.com]

[136] This can be proprietary (Apple, Microsoft clusters) or open (Linux/Open Office).

Mechanism	Description	Example
Banner Exchange	trades banner placement among a network of affiliated sites.	[Barnes & Noble]
Revenue Sharing	offers a percent-of-sale commission based on a user click-through in which the user subsequently purchases a product.	[Amazon.com, Google]
Metered Usage	measures and bills users based on actual usage of a service.	[Some Internet providers]
Subscription Models	users are charged a periodic -- daily, monthly or annual -- fee to subscribe to a service. It is not uncommon for sites to combine free content with "premium" (i.e., subscriber- or member-only) content. Subscription fees are incurred irrespective of actual usage rates. Subscription and advertising models are frequently combined. -- Metered Subscriptions: allows subscribers to purchase access to content in metered portions (e.g., numbers of pages viewed).	[Listen.com, Netflix] Slashdot]
Voluntary donations	in the voluntary donation model, the user makes the content freely available, like that of a musician performing on the street, but solicits donations from users.	[Wikipedia]
Licensing of content and technology	is being considered for platforms (licensing e.g. to TV stations)	[Youtube]

The tech trends interact in different ways with the market, giving rise, enabling or limiting the establishment of certain business models.

Infrastructure Convergence may support business models that increase switching costs. Consumer mobility may be limited in facilities-based competition where consumers are tied to specific content and service providers. Internet users' dependence on interoperability and consistent connection makes it profitable to create and control interoperating technologies 'clusters,' leading rivals firms favour incompatible products to limit customer mobility.

In general, technology trends that preserve Internet openness are seen to favour net value creation. Infrastructure Convergence strengthens ubiquitous connectivity and increases the range of channels by which buyers and sellers (and other parties) communicate. This also weakens the bottleneck power of intermediaries while increasing the global scope of demands and supplies available for matching.

By cutting transactions costs, Infrastructure Convergence makes it easier to capture value through process efficiencies. Endogenous innovation that allows firms to stay ahead of the market and avoid stagnation, arise from the stronger (internal) connectivity of creative individuals. Infrastructure Convergence also affects exogenous innovation; as it becomes more user-centred information needs to flow freely in more democratic ways, creating a "rich intellectual commons" and "attacking a major structure of the social division of labour."

Infrastructure Convergence produces strong 'lock-in' at the infrastructural level and therefore is not expected to suffer abrupt reverses or breakouts, nor to distort other trends except to the extent that vertical effects (foreclosure) and systemic failures (e.g. security, privacy) are not addressed by market or regulatory forces. However, increased functional substitutability among infrastructures should make infrastructure service providers abandon business models based on vertical foreclosure. In broadband provision, we see two very different approaches in operation; the vertically integrated 'Walled Gardens" that dominate in the US (where most citizens have a choice of 2-3 providers, who provide a wide variety of content and services bundled with the basic subscription) or the layered competition model prevalent in Europe, where consumers have a wider choice of providers both of broadband services and (as a result of limited possibilities for vertical foreclosure) online content. The survival of facilities-based or service/price/quality-based competition also depends on regulation. Foreclosure can be prevented by public utility regulation (especially in connection with both common infrastructure and utility computing); abuses of foreclosure can be limited by effective competition between a small number of strong vertically integrated providers; or market forces (competition among many, differentiated firms) can be relied on throughout the value chain.

On the other hand, if convergence is accompanied by effective coordination of key technologies, more restrictive business models will flourish in the infrastructure layer and competition (if it survives) will move to the application and content layers, and may seek alternative means of monetisation as infrastructure service providers use their power to extract platform rents. On the reverse side, firms whose business models depend critically on the ubiquity, quality and affordability of communication infrastructures will increasingly try to influence the platform market. This will be opposed by platform providers in so-called 'two-sided markets' who will try to exploit the complementarity of content and service providers with end-users and consumers. This has already lead to bundling offers where platform providers offer subscribers access to a portfolio of safe and pre-negotiated choices, economising on both search costs and transactions costs such as billing and quality assurance.

Human-computer Convergence

This trend is in its early stage, but the need for risk management and the likelihood of extensive customisation will almost inevitably complicate switching. Human-computer convergence enables the provision of an increasing range of 'niche' services of limited large-scale profitability considered on an individual basis, which will become increasingly important in a long-tail world where the total volume (and value-added) of such niche or fringe offerings exceeds that of mainstream or commoditised goods and services.

Human-computer interface stimulates process innovation through the development within organisations of hybrid or cybernetic systems in which people and machines work together more effectively in pursuit of organisational goals. It also increases range of external stakeholders who can exert efficacious influence over technology and market development.

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At the moment Human-computer Convergence does not seem to meet the conditions for extensive or irreversible lock-in, as it is still in an early stage of deployment in which the impact of business models is limited. In relation to machine-enhanced human experience, one of two restraining forces is likely to play an important role. The sheer diversity of human needs is expected to prevent global lock-in in terms of the functionality delivered. The need to combine interoperability with variety or breadth of connection will force standardisation to the technical or infrastructural layer – thus changing the business model at that level towards the utility configuration. L

Computing as utility

This trend is expected to be associated with more efficient provision of computation services and relatively low switching costs. The extremes are represented by the cloud (as compared to the grid, though both service delivery (business) models which offer improved mobility compared to the present situation where access to advanced computing requires greater investment, knowledge and risk of obsolescence. Also utility computing decreases the advantage of large firms and increases the ability of consumers to take control of and exploit their own activity records and other personal data. Other aspects of the Internet of X make (personal or group) profiles perhaps the most valuable asset in commercial transactions. The Internet has already seen a wide range of business models based directly (Phorm) or indirectly (Google) on the collection, analysis and resale of such information.

Utility Computing is affected by changing business models as it may well suffer inefficient lock-in in the utility layer, which may spread to other layers very effectively, due to the range of 'services' making the transition from specific private commodities to utilities. This tendency is reinforced by the spread of business models that 'buy in' services from other layers and even more by models that benefit from the free or by-product provision of key characteristics. The business models that survive in the infrastructure-using sectors will depend on the affordability, quality and equality of access provided from the infrastructure layer. If the grid (cloud) model prevails in business (resp. end-user, civil society) uses, the connectivity of these two groups in other terms (e.g. in the evolution of shared-participation business models) is also likely to suffer.

The contractual basis on which connectivity, content and other services are provided will also shift. One group of traditional models was based on ownership and sales – this has largely been replaced by models based on access and licensing; the basis for payment is also shifting between flat rate, subscription and per-use, and by indirect revenue recovery models in which the services valued by the consumer are free at point of use. Indirect revenue recovery models are also expanding – in this context, the traditional model was broadcast (one to many) advertising. This became more focused as profile information allowed tailored messages and as click-through and other social engineering methods permitted greater engagement of users in (effectively) exchanging information with other suppliers and negotiating mutually-beneficial deals. This applies to both commercial and 'free' engagements – for instance, Spotify combines traditional advertising with file-sharing and the enormous storage capacity present online to monetise music sharing. It is not possible to predict the survivors of this evolutionary struggle among business n=models. What is striking and novel is the degree to which the new models cross market and service boundaries and the resulting tight linkage between technological or service innovation on one side and business model innovation on the other.

Intelligent Web

Damaging lock-in is weakened by Human-computer Convergence in ways that reflect both the underlying model (grid vs. cloud) and the nature of regulation (if any). This trend can further reduce switching costs by facilitating consistent performance, interfaces, etc. as matters of management infrastructure not tied to specific providers. It also helps firms collectively to control risks and reduce losses associated with systemic problems (malware, security breaches, communications interruptions, etc.). It reduces the costs associated with managing such risks while delivering goods and services – this can be considered a matter of process efficiency except where the products directly concern e.g. network security.

The development of the Intelligent Web may well be affected by the need for effective combination of 'intelligence' at different points in the system, which *could* force a highly standardised engineering-driven approach to system architecture and governance. But recent experience suggests a much more open and flexible system, in which 'intelligence' owes more to creativity than to calculation and in which emergent rather than designed properties hold sway. Eventually each new development in the Intelligent Web will lead to a local consensus and local lock-in; this in turn will demonstrate (for the wider network) the benefits and disadvantages of that lock-in, leading in turn to innovation and break-out and (because societal connections will evolve along with technological arrangements) to a gradual improvement in socioeconomic impact.

Table 10 summarises these trend impacts on the drivers of value creation and capture.

Table 10: Tech trends and drivers of value creation and capture

Trend	Process efficiency	Endogenous innovation	Exogenous innovation	Clustering, lock-in
Infrastructure Convergence	Better communications	More connectivity of creative individuals	Easier to mobilise user base.	Weakens application, service lock-in
Utility Computing	Efficient provision of computation services	Common ICT support for innovation	Development open to users (esp. via cloud)	Depends grid vs. cloud, regulation.
Human-computer Convergence	Development of internal 'cybernetic' hybrid systems.	Enhanced collaboration (e.g. creative use of shared game spaces)	More motivated user input to technology, market development.	Long-term dependence, partnership
Intelligent Web	Collective risk control, lower losses from malware, etc.	Reliability and security of distributed innovation networks.		Can weaken application, service lock-in

3.3.4 Summary comments

The discussion above has raised a very large number of issues, all of which are to some extent policy-relevant. The objective of this section is to draw back from this detail in order to identify some broad issues relating to policy per se rather than the content or specifics of individual policy actions that might be desirable in specific scenarios or more generally. One key element is the importance of *market competition* in motivating and funding the development of innovations and in determining their availability, affordability and the resulting impacts on societal objectives. As a result, even though the competitive landscape will continue to be shaped by technical, sector-specific and social policies, effective competition policy remains essential. This raises new challenges for existing (technical and economic) regulators in relation to IPR, bundling and the treatment of joint ventures. More profoundly, it can change the synergistic relation that has traditionally existed between competition and consumer protection policies. To avoid capture, unjustified market distortion or an inappropriate balance of efficiency and innovation, it is necessary to ensure that competition policy promotes the efficiency benefits anticipated from competition rather than competition for its own sake.

Another important policy issue concerns *discrimination* (or its partial political opposite, *neutrality*). New technologies and business models give firms the power to implement greater discrimination and differentiation in pricing, quality of service, content and other aspects of valued services. Because these characteristics (price, QoS, etc.) are valued differently by different people, and because their provision creates joint as well as separate costs (e.g. infrastructure costs or congestion/contention costs), it is simplistic and inaccurate to assume that all discrimination is bad (or conversely that any form of neutrality is good). Indeed, in many cases, the 'right kind' of discrimination is necessary for profit maximisation, for economic efficiency, for equity and even for the existence of markets themselves (when fixed costs are high, for example)[137]. This is uncontentious, but 'bad discrimination' persists and 'good discrimination' remains unpopular for a range of political and cultural reasons. Some social groups are unwilling to pay for shared content, despite valuing it and having the means to do so (including micro-payment services that can align prices and values for individual songs, etc, without excessive negotiation or transactions costs). In a similar fashion, the principle of price and/or service discrimination is opposed on a priori grounds by some interest groups. However, it seems likely that this will become understood and accepted (as paying for shared content is becoming more viable) once the benefits are made explicit (e.g. in connection with the long tail) and adequate safeguards assured.

As noted above, it is possible to distinguish value creation and value-capturing strategies. These differ in their sustainability and societal spill-over benefits, but the inherent advantages of value-creation are no guarantee of their survival in the evolutionary struggle between business models. The presence of non-commercial as well as commercial players – and their greater attractiveness on cost and cultural, if not necessarily performance, grounds – complicates the picture as well. Even non-commercial models can have strong elements of value capture, e.g. in relation to the ideological aspects of the Open Source movement.

Innovation is likely to become even more important as the basis for commercial success shifts away from commoditised offerings or as commoditisation and homogenisation are pushed down into the infrastructural layer. For instance, basic computation services are likely to follow basic communication and connectivity services from a competitive resource based on large-scale end-user investment and ownership to provision of a fairly uniform service with minimum guaranteed levels of affordability, reliability and quality. Innovation

[137] See e.g. Cave and Marsden (2007).

in this layer will take the form of a convergent race to provide ever higher levels of functionality and cost-effectiveness. Differentiation and divergent innovation will be stronger in the user-facing layers. As a direct result of the increased common provision of connectivity, computation and information exchange necessary to innovation, it is also likely to become more 'democratic', with companies striving to promote endogenous innovation in order to stay ahead of the market and avoid stagnation, using the stronger (internal) connectivity of creative individuals. In addition, customer feedback is already becoming a necessary source of new ideas, building on the complementarity between users (who know or discover what they want) and firms (who know or discover how to provide it). This is leading to higher levels of shared and sustained engagement, whereby firms share much more content, hardware, etc. with customers on a no-cost or low-cost basis during the initial development phase in exchange for feedback that converts invention to innovation.

3.4 Summary of the (projected) impacts of the 'Internet of X'

The preceding analysis has identified a range of economic, social and business model impacts. For the most part, these were developed from analysis of the three indicative scenarios. But it is important to stress that the scenarios were not themselves predictions of what would happen, but rather a means to understand the relationships among the various drivers of development of the Internet of X and the economy, society and commercial environments that will accompany it. Some of the impacts were scenario-dependent in the sense that they would be very different (or absent) if the critical uncertainties used to define the scenarios resolved in one way or another. But other impacts are robust – they are likely to occur regardless of how the future develops, based on current trends. In this section we extract a range of such robust impacts. These will be used in the next chapter to derive policy implications – some of the robust impacts listed here will need policy attention, and some of the scenario-dependent impacts will call for adaptive policies or actions whose formulation and implementation should be delayed until the future becomes clearer.

3.4.1 Economic Impacts:

- Growth (at least in Europe) becomes increasingly capital-efficient.
- On the other hand, investment in the BRICs continues to outpace GDP growth, indicating that their real potential for economic dominance lies beyond 2025 and thus that Europe faces a long-term challenge in maintaining its strong position
- GDP per capita understates the true social cost of the connectivity failure, given the likely higher rates of unemployment,
- Knowledge capital is currently a brake on MFP growth, meaning in rough terms that it attracts more payment than it deserves (possibly due to persistent market power in the control of intellectual property rights). Free access to ideas can reverse this as it makes visible the potential return to their shared exploitation.
- A focus on monetised returns understate productivity gains in peer-based, open-source and other unpaid production. To assess productivity growth in the Internet of X these also need to be accounted for

- At a global level, physical capital continues to retard multifactor productivity growth, although this is easing as new technologies reduce the deadweight loss of 'bottleneck' proprietary infrastructures (in all scenarios).
- While governments in general are becoming less powerful (asymmetries of power among nations are weakening), the technological power of the leading countries is increasing.
- Growth of inequality within as well as among nations: will initially decrease in open and business driven economies. But as market power consolidates and prices rise, the poorest nations and individuals again begin to fall behind. This can be partially ameliorated by a combination of stronger public sector engagement and greater openness (of technology and economic activity), which tend to promote a more sustainable and equitable society with long term decreasing inequality. As a result, interpersonal inequality increases in two out of three scenarios: the Connecting and Scattered Worlds
- Greater connectivity and globalisation of financial and other markets tend to change economic dynamics; with strong public sector regulation (or effective self-regulation) this may promote short-run stability, but increase the changes of sudden (global) shocks in the medium term. Without effective regulation, complex short and medium term dynamics can produce sudden shifts in the availability of capital which in turn increase the volatility of expectations formation. This can produce either a sudden shift of capital to new technologies, business models or goods and services or a collective reluctance to abandon the status quo in favour of risky alternatives. Whether excess volatility or excess inertia (compared to the efficient variation implied by technological and commercial fundamentals) prevails depends strongly on recent history, making random shocks more persistent than they were before.
- With regard to economic policy, the combination of large shifts, global impacts, the availability of a wealth of real-time information and the possibility of using technology to implement sophisticated regulatory strategies can create an imperative for more active and continuous intervention. This can produce a fallacy of control; the growing *complexity* of the economy may render such actions less effective than hoped, generate a greater range of unforeseen consequences and possibly even contribute to economic instability (if authorities are too reactive) or inertia (if they become too risk-averse and therefore unwilling to stake political capital on policy changes whose consequences cannot be perfectly foreseen).

3.4.2 **Social impacts**

- The anticipated period of rapid and continuous change has many overt and subliminal socio-economic impacts which over time affect values, governance structures and business models. Governments need to be very aware of these trends, which have a strong disruptive potential – for good as well as for bad.
- Rationality, intuition and beliefs (religious or other) are being rebalanced at the individual as well and the societal level. Professional instruments and networks provide individuals with disproportionate influence, whilst also disenfranchising people who cannot use the tools and who feel overwhelmed.
- As with the economy, in the social sphere the growing complexity of interaction, the abundance of data (if not necessarily information) and the increasing salience of social

policy may lead either to excess inertia or excess volatility. A reluctance to engage with complex changes can lead to gradual erosion of control, while the political imperative to respond to commonly-recognised challenges with innovative solutions can lead policy makers to embrace (and abandon) 'state of the art' initiatives with undue haste. Decision makers must therefore carefully balance leadership and pre-commitment against power-sharing and adaptability.

- More intermediation is expected, to manage information streams and wide networks of social ties. Intermediaries may also get 'bottleneck' power because people cannot or will not bypass them, which may cause inefficiencies.
- Bonding, bridging, and linking social ties are all relevant. Weak ties matter as much as – and for some purposes more than –strong ones. A world that encourages the formation and use of many weak ties may be more innovative – and more risky - than one that facilitates strong (and therefore less numerous and diverse) ties.
- Tech trends are likely to further blur the distinction between private and professional spheres especially in combination with the emergence of a large group of "prosumers" (individuals acting both as producers and consumers, or migrating between the two roles as technologies and service offerings mature)..
- Tech trends such as Utility Computing and Infrastructure Convergence offer platforms for bottom-up engagement with government and encourage policy making that is more actively driven by citizens and hence more responsive to their (direct) needs.
- A strong public domain also allows citizens, civil society and business – for better or worse - a platform or 'landing place' for its active participation and involvement, without which empowerment through web 2.0 (and 3.0) tools and unlimited access to information will not be effective.
- The centrality of collaborative behaviour is likely to drive demand for soft skills and make them a central focus of education. Human-machine interfaces are likely to become increasingly intuitive, easy and less reliant on user (technical) expertise, as the tech trends such as Human-computer Convergence and the Intelligent Web move complex technical decisions from the end points to the centre of the network..
- Education is likely to become an increasingly critical national as well as personal asset if the job market of the future is as global as the flow of goods and services. Combined with Internet of X possibilities to deliver participative and interactive educational experiences as well as 'mere' curricular content, this may possibly lead to dominance of 'branded' education provided by commercial elite institutions and thus increased inequality of access and skills. Other potential impacts include limited access to skilled positions by those with 'second tier' skills and loss of intellectual diversity.
- Large global companies will invest more in attracting than in retaining talent and skills. A by-product will be the emergence of online (public and private) services to enable workers to manage their own training and social security across Europe and possibly globally.
- The European Research Area concept aims both to produce a richer set of research outputs and to increase individual incentives to develop human and social capital. The same approach can be applied to the educational 'strand' of the educational establishment to

induce students to benefit from the rich supply of education across Europe through common standards and joint educational programmes. Without such rationalisation there may be over-supply of education without sufficient variation.

- Work and careers will develop (at the higher skill levels, at least) a portfolio character, which will increase the resilience of individual employment to changes in the labour market and internalise much cross-cutting or 'tech transfer' innovation.

3.4.3 Business model impacts:

- In general, technology trends that preserve Internet openness are seen to favour net value creation, while those that enhance proprietary restrictions and reward lock-in favour net value capture as a rationale for business model evolution.
- Dominance of global business brings certain benefits of integrated service offerings based on proprietary standards, leading rivals firms favour incompatible products to limit customer mobility. This may threaten diversity and competition due to technological lock-in and rent seeking behaviour.
- Increased functional substitutability among infrastructures should make infrastructure service providers abandon business models based on vertical foreclosure for more competitive, utility provision models.
- Firms whose business models depend critically on the ubiquity, quality and affordability of communication infrastructures will increasingly try to influence the platform market. This will be opposed by platform providers in so-called 'two-sided markets' who will try to exploit the complementarity of content and service providers with end-users and consumers.
- Small innovators may find it hard to enter markets as incumbents aim to capture as much value as possible through technology lock-in at the infrastructure and platform levels or through coercing innovators to join existing IPR and interoperability clusters.
- In view of the point raised above the role of the government is thus important as arbiter and enforcer of fair competition policy, in which it is necessary to ensure that competition policy promotes the efficiency benefits anticipated from competition rather than competition for its own sake.
- However there will be many small suppliers of services to the platforms, as companies seek the speed, creativity and volume of large and diverse populations to develop (e.g. crowd sourcing) and to consume (e.g. the long tail) new formats and applications.
- Human-computer convergence will enable a high degree of customisation which will almost inevitably complicate customer switching. It enables the provision of an increasing range of 'niche' services.
- In principle, utility computing decreases the advantage of large firms and increases the ability of consumers to take control of and exploit their own profiles (including activity records and other personal data)..
- The services will be increasingly paid by licensing and less by advertising. New technologies and business models allow greater discrimination and differentiation in pricing, quality of service, content and other aspects of valued services. Because these are

valued differently by different people, and because their provision triggers joint as well as separate costs (e.g. infrastructure costs or congestion/contention costs), some form of discrimination is necessary for profit maximisation and for efficiency and equity.

- Innovation is likely to become even more important as the basis for commercial success shifts away from commoditised offerings or as commoditisation and homogenisation are pushed down into the infrastructural layer. Differentiation and divergent innovation will be stronger in the user-facing layers. It is also likely to become more 'democratic', with companies striving to promote endogenous innovation, using the stronger (internal) connectivity of creative individuals, customer feedback, and other forms of 'commercial inclusion.'

This summary list of impacts provides some indication of future issues that policy makers should take into account when dealing with a context moving towards the Internet of X. As repeatedly mentioned, the uncertainties of how this future may unfold are such that no precise predictions can be made about specific socio-economic outcomes and the link to tech trends. Even the speed and development trajectories of individual tech trends and their interactions are fraught with uncertainty. Nevertheless this chapter provided indications of the trends and impacts; and how governance, market and technology variables can influence these.

The listed impacts should support policymakers in understanding the socio-economic context and possible effects of policies relating to the future of the Internet, In the next chapter the impacts and trends will be assessed from a policy perspective to identify what policies prove to be relevant in all three scenarios, and thus demonstrating a certain level of robustness in the face on deep uncertainty.

CHAPTER 4 Policy Implications of the Internet of X

The tech trends, and their expected impacts, were discussed in a scenario gaming workshop. The initial three scenarios were used to identify strengths, weaknesses, threats and opportunities that these futures would bring. The participating experts were then asked to look back from the 'future' with the benefit of 'virtual hindsight' to recommend actions that should have been taken earlier (in the period 2009-2020). Based on these inputs a single scenario was drawn up (presented in section 4.1) to allow a review from an industry, citizens and government perspective. This chapter assesses the list of policy issues that were identified and puts these in the context of other recent policy research in these areas.

4.1 A revised scenario for 2020: Connected Boundaries

Based on the feedback from the sessions per scenario, a new view on the future was developed. While this is not a prediction of 2020 in one way or another, it does take into account the feedback from the first three scenarios on what participants would like, and what they would like to avoid in such a future, and what they collectively believe to be reasonable expectations of likely development.

2020 revisited 'Connected Boundaries' is therefore a slightly optimistic scenario. Its purpose is to provide a background, against which effective policy action may be considered, and as such the starting point of the discussion about policy action rather than *the* result of the workshop effort.

This new scenario is positioned closer to the centre of the "scenario space" (the range of uncertainties and opportunities spanned by the three initial scenarios, which represented extreme outcomes). It is not in the exact centre – based on the discussions in the breakout sessions, it is located slightly off-centre on two of the three dimensions: these two dimensions are that it is more open than closed; and it is also slightly more competitive than collaborative. On the governance dimension, it is centrist, with a balance between public and private influences.

The picture below highlights the "bear traps", and, in the middle, reminds us that we also took the "honey pots" into account when we developed this new scenario. Bear traps are the risks, weaknesses and tradeoffs of each specific scenario. The honey pot is a collection of preferred outcomes combining the strengths and opportunities of the three initial scenarios. The arrows indicate the balancing act to manoeuvre between the bear traps to achieving more favourable outcomes.

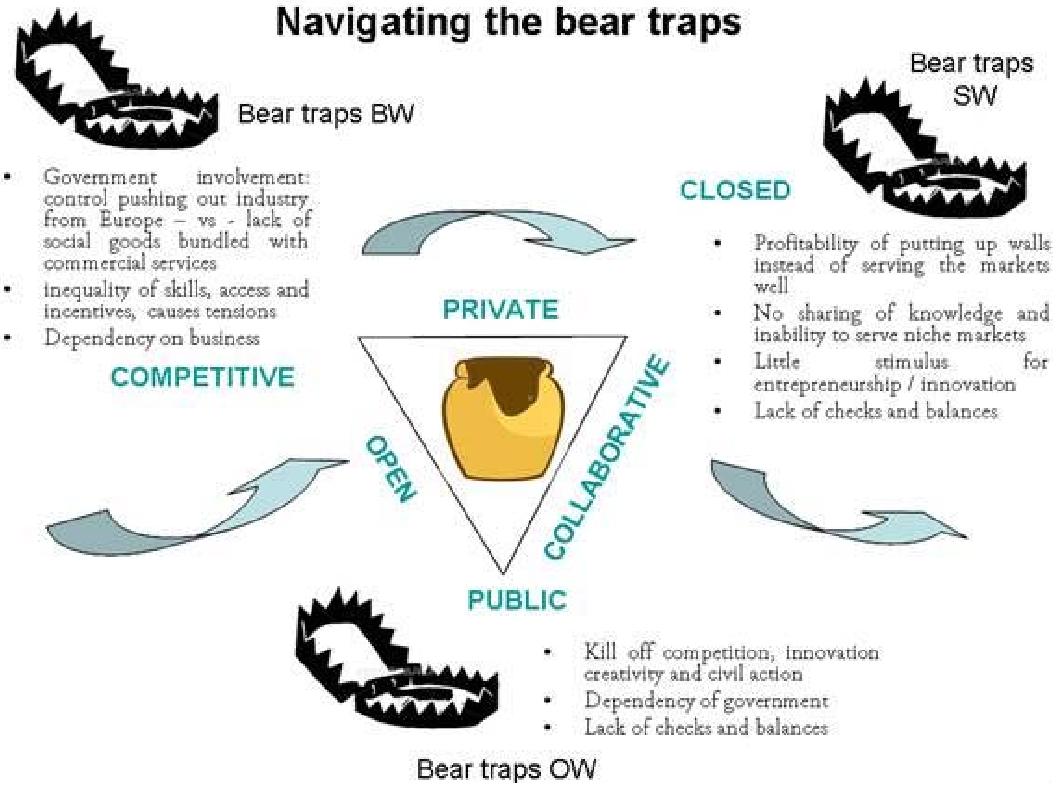

Figure 26: Bear Traps and honey pots

Characteristics of '2020 Revisited; Connected Boundaries':

- There is plenty of choice among products and some good quality services. Governments play an active role as guardians of the public interest and act on behalf of their citizens. In this they assume responsibility as guarantor of key public services, which are not necessarily provided by Government Agencies but where government can serve as provider of last resort. In this society, structural investments (e.g. infrastructure, basic research, etc.) are made by public-private partnerships involving collaborative partnerships between commercial, non-commercial (private and public) and government players.
- The available networks are open, interoperable and allow connections among and between people and businesses independent of geographic location, at reasonable cost and in a non-discriminatory and non-exclusionary manner, as inclusion continues to be highly valued.
- The economy itself is fragile. The European recovery has been slow compared to the rest world, although the recession was less deep because European governments in particular sought to cushion the damage suffered by the most vulnerable. This concern with societal welfare, and the pattern of expenditure that implemented it, slowed the economic recovery. The length of the crisis and perceived difficulty of rebounding has caused a lot of debate about whether the EURO zone remains (or ever was) an efficient (coherent) currency area. Strict monetary policy and the strategy used to implement the Stability Pact have been criticised because, by slowing Europe's macroeconomic recovery in relation to

other powerful global economies, the socioeconomic sustainability of the "European Model" is cast into doubt.

- While inclusion remains high on the political agenda, inequalities between states within Europe have increased. Nonetheless, Europe retains its allegiance to its founding values and principles, seeking to engage all citizens and businesses in its policy development. Society has, however, progressed in striving to balance social equity and diversity by promoting equality of opportunity rather than equality of outcome. Constructive social conflict is accepted, encouraged, and facilitated.
- Europe's role in the world has developed into intermediation among global extremes, and highly connected European "main ports" (in transport, but also in the flow of information, ideas and policy) play increasingly important global roles. In essence, Europe has become a highly connected hub in a global market by providing benefits on a utility basis to all who choose to use European Information Space:
    - Transaction support
    - E-Identity
    - Connectivity, high bandwidth and interoperability
    - Privacy
    - Security, resilience
- As world competition (and even conflict) continues, part of the attraction that supports European centrality is her reputation as a relatively neutral player able to mediate between global players with very different values who nonetheless need to interact and come to depend on arms-length interactions brokered by a mutually trusted party.
- Strong competition policy, including regulatory measures and monitoring are used to sustain a level of effective competition that provides incentives for investments in infrastructure and its innovation, minimises harmful lock-in and fosters meaningful consumer choice. Standards development and fundamental research become increasingly collaborative, and Intellectual Property Rights (IPR) based on a principle of fair and adequate (but not excessive) return are protected in new ways, mindful of the need to stimulate new as well as traditional approaches to the exchange of knowledge without creating (or promising) excessive market power. Not all of this is a matter of command-and control: control is increasingly co-regulatory, promoting self certification, self-regulation and voluntary compliance while monitoring performance and providing State support and pre-emption where needed. This stance is intended to protect the interests of both consumers (consumer protection) and businesses.

This scenario was reviewed by experts taking three different stakeholder views: Citizens, Government, and Business. They assessed strengths and weaknesses, opportunities and threats based on their specific interests. After this analysis they identified policies and attributed these to one of the three stakeholder groups.

The results of this scenario game have been analysed and where necessary strengthened on the basis of existing literature, to allow the formulation of a policy issue list, which is presented in the next section.

4.2 Key Policy Issues identified in the Workshop

Based on the revised scenario and the role play of citizens, industry and government a number of key policy issues were identified as arising in the Internet of X 2020. These were categorised under five headings: Core Values and Principles, Architecture and Design, Uncertainties, Leadership and coordination, and finally policy instruments: The full list of issue is:

Core values and principles:

1. A review of the concept of privacy and the means to protect it
2. The key importance of trust
3. The central concept of identity – group and individual

Architecture and design

4. The benefits of open networks and how to ensure this; including Net Neutrality
5. Interoperability, and the architecture of networks
6. Open standards
7. The extent to which public good services/controls need to be deployed inside the network

Uncertainties

8. Availability of and access to new infrastructures (creating the incentives to invest)
9. Competition and the risks of technology lock-ins

Leadership and coordination

10. Horizontal nature of connectivity and the role INFSO can play as an expert centre of catalyst inside the EC
11. Need for public leadership in setting the EC agenda and influencing global ICT/Internet policies

Policy instruments:

12. Multi-stakeholder networks and governance principles
13. The increasing importance of technologies as policy tools
14. The increasing role of self- and co-regulation; exploiting and supporting 'self-correcting' market mechanisms
15. Better and more strategic use of procurement

These core policy issues are discussed in more detail in the following sections.

4.2.1 Core values and principles

A review of the concept of privacy and the means to protect it

The policy issue is how to (re)set the scope of privacy and to decide in conjunction with this whether privacy needs to be (or can be):

- reinvented for the networked environment with new laws and regulations sitting next to those already in place (in which case associated concepts such as 'data ownership' and 'informed consent' need re-examination);
- reinvented (and re-established in law) on a consistent basis for both networked and non-networked environments (in which case a more explicit basis for a fundamental right to privacy may be appropriate); or
- 'tidied up' by minor fixes to existing privacy law and regulation and necessary minimal adjustments to other laws and regulations affecting privacy issues.

A related issue derives from the well-documented need to consider the first/third pillar priority question and ask whether existing EU (and foreign) structures giving priority to security concerns provide the best basis for addressing this issue, or whether instead only the basic privacy right of EU citizens and 'crash barriers for security access' should be addressed at EU level. Security/privacy trade-offs would be established by Member State implementation and bilateral (data exchange) negotiation, with the EU collecting and publishing comparative information. Given increasing government initiatives that encroach on the boundaries of the private self and the associated subsidiarity and proportionality questions, some participants favoured the latter approach in the hopes that bilateral pressure and the reputational effect of comparisons among Member States might improve the standing of privacy either in policy circles or the attention of a voting that has good engagement and a chance of influencing policy.

While the concept as such will have changed by 2020, it is still expected to be important to retain some form of fundamental right to privacy. This could be government driven (data protection frameworks), business driven (self-regulation, privacy at a premium), or citizen driven. Key challenges in data protection and privacy are likely to be[138]:

- Risk assessment – can we predict how risky it is to provide our personal data to an entity or organisation?
- The rights of the individual in relation to the benefit of society – under what circumstances can personal privacy become secondary to the needs of society,?
- Transparency – personal data is everywhere, particularly online, and through technological developments such as ambient intelligence and cloud computing could become increasingly difficult to track and control.
- Exercising choice – many services are only provided after sufficient personal data is released, but if important services are denied when we are unwilling to supply that data, do we still have a real choice?
- Assigning accountability –who is ultimately held responsible and where do we go to seek redress?
- Complexity – as the variety, location, ownership and potential (esp. third party) uses of information expand, it becomes increasingly difficult either for individuals to

[138] Robinson *et. al.* (2009).

exercise effective control over their data or for systems to provide adequate levels of assurance and protection against error, attack and coordination failure.

- Joint privacy – as more information is collected about interactions between individuals, issues of joint ownership and control may be expected to arise.
- Persistence and mutability – personal data (and evaluations or decisions based on such data) are unlikely to 'disappear' from the Internet – this effectively creates a potential overhang effect that can distort individual incentives to manage and benefit from personal data profiles, especially when data arising from different sources can be 'mashed-up' or recombined in arbitrary ways.

In 2020, the copying of personal data of one version or representation of a person would be likely to have an impact upon another 'version'. Certain classes of content might not be available outside certain contexts (e.g. streaming which is ephemeral until you purchase the movie).

A future proof approach to data protection is likely to be driven by previously determined outcomes and guided by general privacy principles. It will also be more risk based and include stronger personal liability and redress instruments. In addition to regulation and judicial instruments it is expected that by 2020 technical measures would be available, up and beyond application of Privacy Enhancing Technologies (PETs) and commercial privacy services would be provided (e.g. facilitating revocation and data removal from Facebook profiles). Examples could be:

- *Watermarking* of personal data: If a user deletes something from one location a deletion request goes out to all other repositories of identical or related data.[139]
- *Copyright model* – when profiles about you become useful property to others, maybe privacy as a fundamental human right could possibly be supplemented by rights as a property right. [140]

From this it emerges that the user has to be in control and should have the right and means to track back and see how his data has been used. Permitting such revocation and legal control methods, leads to a further increase of complexity of the network architecture. For this it is fundamental to settle for certain principles; possibly data stewardship.

The importance of trust

Trust is a multi-stakeholder concept, and involves an evolving range of levels and forms. In a global context, governments will no longer be the final arbiter. Hierarchical, top down approaches conflict with the end-to-end principle[141], which is at the heart of the Internet. A trust model might work when based on a more equal or equitable partnership (peering)

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[139] See e.g. The KIM Project: Immortal Information and Through Life Knowledge Management: Strategies and Tools for the Emerging Product-Service Paradigm at: http://www.kimproject.org/

[140] Limitation to these rights already exist in EU data protection law – e.g. in the course of prosecuting criminal behaviour, national security etc (although there is uncertainty with regard to 1st / 3rd pillar applicability of current EU law).

[141] See footnote 4

between actors. This requires a sustainable business model – which has to be implemented on a peer to peer basis, globally.

Supporting trusted environments:

- Enabled through transparency, which would be provided through technological solutions and be embedded in a legal framework.
- Trusted Third Parties (TTP) may be considered to be an intermediary for the trade off between open and closed networks - which each has its own benefits. In a borderless world, and by definition multi-stakeholder environments, government bodies would probably not be the most logical TTP.

The central concept of identity – group and individual

Identity is a critical concept under development, and will provide the keys to information by 2020. Consideration of identity changes when you are in a group or 'alone' – this will need to be taken into consideration. The shared group identity might have different preferences that are at odds with that of the individual. A subject for research is to consider how such a group would articulate its rights in regard to privacy and how might these rights might be agreed upon, or changed?

4.2.2 Architecture and design

The benefits of open networks and how to ensure this; including Net Neutrality

Openness and open networks bring many advantages, including more opportunities for innovation as knowledge is widely available. At the same time it brings more risks to privacy. It is recognised that there is a trade-off between requirement for data protection and the value of using information for innovations in an open network. In a closed network or walled garden it is very easy to obtain privacy since a lot of the intelligence can be built into the network.

The world of 2020 is expected to allow for differentiation by quality of service; i.e. has premium services, but also ensures a minimum level of service. Issues of differentiation, discrimination, control and what you access will become important. In light of the Net Neutrality discussion it is thus expected that pure indiscriminate openness will give way to a more hybrid situation of fully open networks for basic services and QoS models for premium offerings.

Interoperability, connectivity and the architecture of networks

Interoperability is as much a technical as a strategic economic issue. Most ICT solutions could be IP based or use other open protocols and standards; however this is rarely in the interest of dominant market players.

Building on the previous issue of openness; questions relating to the architecture of future networks include whether interoperability needs to be established at data or application level, or at lower layers of the networks. The challenge will be to keep the architecture whole and coherent if you move for a network with more 'intelligence' built in.

It is appropriate to consider 'horizontal' and vertical connections in this context[142]. *Horizontal interconnectivity/interoperation* – whereby the 'ends' of the market do not need to 'go through' a closed or proprietary platform in the middle in order to reach each other, compete, realise gains from trade, etc. If interoperability is limited, then consumer mobility is limited (which in turn limits competition) and so is the ability of users to create their own bundles or 'bottom-up' innovations.

The problem for future public intervention to achieve horizontal interoperability will be twofold: 1) it is not obvious who to regulate or how to do this - unless (as in some aspects of the ONP Directive) there is enough significant market power (SMP) to justify a dominant firm targeting strategy. 2) Interoperability is rarely passive: e.g. if A interoperates with B, this does not mean that B interoperates with A; or the costs and commercial consequences of interoperation do not fall evenly on the interoperating parties; interoperation that facilitates competition may reduce initial profit margins, which can lead to slower pace of innovation, it may also require sharing of proprietary knowledge before its development costs have been recouped. etc.

In the case of *Vertical interconnectivity*[143] the bottlenecks that have to be removed are technical, organisational, price, and other barriers. Here the challenge will be to address the two-sided market/net neutrality issues, whereby a platform provider (or network service provider) wishes to discriminate against rival providers of content and services offered over its infrastructure by raising impediments like: *technical* - e.g. incompatible technologies or standards; *operational* - incompatible business/accounting models, barriers to co-location, adverse prioritisation, etc.; *quality-of-service based* - traffic shaping, latency, etc.; *price-based* - charging exclusionary or foreclosing prices to rival suppliers for use of the platform, *informational* - suppressing or limiting information about rival offers, manipulation/exploitation of end-user profiles, etc. and/or *transactional* - offering bundled or facilitated billing services, enhanced warrantee and customer service, etc. These different methods of strategic manipulation have different levels and patterns of social cost and distortion of current service quality, social benefits, investment incentives, etc.

The legal and economic basis for promoting interoperability may differ in the different 'modes'. For example, technical interoperability may be predicated on safety or (technical) efficiency objectives, while economic interoperability may be based on open competition - to give a specific example, the EU approach of promoting openness at system boundaries works well as along as each 'layer' of the system retains enough surplus to support and motivate innovation, investment and quality competition, but may require public subsidy if e.g. the infrastructure layer has to accept very low ROI in order not to exclude users. Similarly, the 'societal pricing' needed to ensure inclusion and 'universal service' may require subsidy from rival providers, inelastic (or rich) users, etc. - and thus departs from the free-market (allocationally efficient) outcome.

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142 There is a degree of antecedent regulation and law, starting with the ONP Directive, that establishes both the basis for EC action in this area and the (general kind of) policies that can be used.

143 This is largely covered by existing frameworks involving 'essential facilities,' critical infrastructures, common carriage or easements;

This should *not* be seen as a set of things the EC cannot do. Rather, it should be seen as calling for an explicit and clear identification of the cross-impacts of individual interventions and the synergistic effects of combined polices. Any assessment of possible interventions for increasing interoperability must start by identifying when interoperability is good and when it is bad, and for whom it is good or bad. But also, who can be regulated or subsidised and how static and dynamic considerations trade off against each other.

- Interoperability is *good* if it facilitates competition (among firms producing potentially interoperable goods and services) either directly (horizontal) or via platforms (vertical). It is *bad* if it creates anticompetitive clustering, facilitates collusion among firms and discourages 'breakout' innovation.
- Interoperability is *good* for firms on the outside that get to interoperate with an incumbent, and may be good for customers if they don't get locked into a walled (but highly interoperative) garden. It *may or may not be good* for security - it creates joint ownership, but makes threats potentially more serious and widespread (and thus provides a more attractive target for malware authors). It may lead to loss of diversity (as the commercially strongest element in the interoperating cluster triumphs).

Open Standards

Interoperability and open standards - are part of the same issue. [144] Open standards apply in one way or another to all tech trends:

- *For infrastructure convergence*, they allow the 'higher layers' to derive maximum benefit from the infrastructure layer - though this might also prevent some kinds of innovation either because shared returns are insufficient to reward investment or because a service or infrastructure that is fully interoperable with all existing applications may not be able to offer the novel functionality that makes it valuable[145].
- For *Utility computing*, they allow the 'cloud' to find an optimal architecture, because different modules can be plugged together to provide new (and new combinations of) functionality. On the other hand, this again can limit returns to innovation and the ability of cloud service providers to control the use of the facilities they provide (and thus to manage the liabilities they may incur for storage, integrity, quality, privacy, etc.).
- For *Human-computer convergence*, open standards again facilitate diversity of innovation in both directions: new 'bit's of human experience enhancement can be developed without the losses observed already in video games ('platform wars' and costs of porting). For the use of humans to extend computation, it increases the reach of cybernetic systems and in particular extends participation beyond elites or closed groups.

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[144] See also for a discussion on open standards: Undheim (2008).

[145] i.e. interoperability changes the ability to control parts of the application and also carries an obligation of backwards/outwards compatibility that may reduce functionality, performance or reliability

- For the *Intelligent web,* they allows 'smart' elements of infrastructure management to be deployed across a range of interacting systems (e.g. wired and wireless) and thus allows the system to rebalance end-to-end with smart network aspects.

The extent to which public good services/controls need to be deployed inside the network

Policy will need to address the discussion about the end-to-end principle, which has been at the heart of the Internet architecture, basically accepting the network as a black box with security and other featured concerning the users, being applied at the edges (i.e. in private computers and networks). The principle either needs to be reconfirmed and strengthened, or reviewed, possibly by putting security and other 'public good' controls in the network. Here the Commission has no direct formal role, however it has responsibility as the shift of various controls into the network is affected by formal powers like telecom regulation, assignment of liabilities (e.g. ISP liability for IPR infringement), guidance to the Member States (e.g. in relation to adapting the ONP Directive to the new world, etc.).

The EC may provide an intellectual contribution by researching the practices of ISPs, and the technologies and use of deep package inspections. In acknowledging this trend the EC can help broker an EU position and vision on the risks and benefits and articulate a new concept of controlled openness.

4.2.3 Uncertainties

In 2020 we will need to be able to act without knowing exactly what the situation is – we need to be comfortable with uncertainty. That requires having the right values in place to deal with the 'Black Swans', disruptive technologies and creative destruction, even if we do not know what this will entail and how it might work out. In this section we briefly describe a few critical uncertainties.

Availability of and access to new infrastructures (incentives to invest)

It is uncertain who will invest in new generations of infrastructure and what model will prevail. Traditionally infrastructure investment was provided through monopoly rents associated with regulatory barriers to entry (and/or rate-of-return regulation to recover fixed costs), but now such investment can be provided possibly through other models of revenue generation. The benefits of the infrastructure are shared by many, but it is difficult to make them contribute – i.e. free-rider problems occur. Note that the form of intervention is important here. Using 'rate of return' regulation there is a proven tendency to overinvest in capacity (the Averch-Johnson effect), which can further delay and distort the development of technology trends. On the other hand, the casual use of 'incentive regulation' (esp. price caps) can lead as easily to too little investment and innovation.

Increasingly, incentives have been provided by complementary support for service and business model development to provide 'pull' factors (e.g. TEN-telecom, later eTEN), opening up infrastructure provision to other networked facility providers (e.g. electricity, transport utilities), creative (co)financing (e.g. through ESF), publicly-provided infrastructures with contracted-out or auctioned operation (e.g. Stockab), etc. Even more innovative methods can be devised, such as shared ownership that combines equity stakes with usage rights, which are tradable among service providers, Thus a basic principle *might* be to separate the construction (and operation) of physical infrastructures from the (potentially) competitive provision of services over the infrastructure. This involves more vigorous use of structural separation as a regulatory tool. A less stringent proposal could be the periodic reallocation by auction of the ownership of the infrastructure and the associated obligations (including maintenance and extension). In addition, there are a variety of 'mixed mode' models whereby the State either takes an ownership stake in the (public or public-private) corporation that owns and operates the infrastructure or builds and owns key parts of the infrastructure, making them available to the rest of the industry on suitably non-discriminatory terms. Something similar has been analysed for allocating and pricing access to electricity distribution grids. In conjunction with both the 'convergent infrastructure' and 'computing as utility' trends, one could consider similar approaches (e.g. National Grid, the interconnect arrangements between Finland and Sweden and the capacity trading systems that link other electricity networks).

A further important point is that the restrictions and inefficiencies of existing infrastructure governance (leading to excessive investment, deficient provision of capacity, lower-than-optimal quality, higher-than-optimal pricing, churn, etc.) contributes to the growth of alternative infrastructures (fibre, cable, wireless LAN, mobile, etc.). While each is valuable in its own right, there is little doubt that even the modest degree of facilities-based competition experienced in Europe has led to a misallocation of traffic among these modes (compared to their technological strengths and weaknesses) and thus distorted uptake and the development of services and applications in other parts of the value chain. This has important impacts on connectivity, for example:

- between VOIP and land lines
- among subscribers to different mobile networks (possible, but pricey)
- across international boundaries (roaming charges)
- from users of mixed traffic streams (differential charging for voice, data, streamed content, etc.)

These limits amount to market segmentation which may be discriminatory and which undermine the infrastructure convergence trend.

A related matter is that of Universal Service and access to high speed broadband. At different stages, the focus is on coverage, interconnection, quality of service (including bandwidth and speed (though these terms are often used interchangeably), etc. The progress is not one-way; the proliferation of high-speed broadband on top of the basic (Universal) level in cities and other favoured areas has resurrected the basic connectivity issue, with many rural areas unable to connect with the speed and reliability needed to participate or even to compete. Different models of infrastructure ownership pertain, requiring different actions to ensure access:

- Impose Universal service/continuity, interconnection, pricing requirements on any such 'owner' (essential facilities doctrine)
- Make the same transition for infrastructures owned by diverse (and small) agents that we did for telecoms: moving away from dominant monopoly regulation to managed competition.

Preserving QoS and interconnection will be the main challenges, so simply opening up ownership or compelling access will not work (examples from US of civic networks; counterexamples of municipal networks from NL/De).

An interesting example of achieving interconnection and sufficient QoS is that of the link between mobile and fixed infrastructures. Aside from different business models, they have very different regulatory structures in operation. There are some basic principles behind this - spectrum is a non-produced but congestible common pool resource, whereas wires and cables are physical capital - produced and maintained by investment and not directly subject to interference. Some of this will disappear with technology-driven convergence, but some will remain as regulation and business model competition interact strongly. If mobile and fixed-line telecom operators were subject to the same regulatory principles and tools, their business models would not be so different - in particular, in the UK the separation was driven by a combination of the 'dominant monopoly/duopoly' style of wireline regulation and the excessive debts associated with the 3G license placements (which necessitated spinning off the new mobile operations). But there is no automatic presumption that they should be put together. There are quite clear and concrete rules, for example, determining when telecoms operations should be subject to functional, accounting or operational separation - this is a regulatory intervention in the 'natural' (market-determined) business model. The fact that they offer both substitute and complementary services does not mean that these should be provided by the same firm (see above discussion on interoperability for a hint on the 'bundling' arguments on both sides).

Competition and the risks of technology lock-ins

Competition will be an important instrument to ensure societal development and availability of access and capacity of networks, including innovations on the network. However, competition cannot be left to the private sector alone as there are natural tendencies to monopolistic behaviour, in particular in the lower layers of the OSI model, and as pairing commercial offerings with social interest offerings (e.g. Universal Service) is key, sustainability of networks and sustainable financing of infrastructures needs to be ensured. In terms of standards for service and service quality, the user becomes the focus.

Through the creation or coordination of multi-stakeholder platforms and networks, and by applying multi-stakeholder governance principles, the EC can help to encourage efficient competition among technologies and discourage inefficiently-high incompatibility. These would be enabling the adoption of common standards and market wide approaches to public policy concerns.

4.2.4 Leadership and coordination

Horizontal nature of connectivity and the role INFSO can play as an expert centre or catalyst inside the EC

In view of the crosscutting nature of Future Internet policy issues and the importance of connectivity to almost every aspect of Information Society development, it is important to ensure that connectivity aspects are taken into account in formulating all EC policies (connectivity awareness).

Much impact may be expected from linking the benefits of ICT and connectivity to the overarching strategies in the EU: energy and climate; growth, innovation and competitiveness; inclusion and empowerment; and the Single Market. Beyond this, connectivity considerations directly underpin many aspects of policy coordination within the EU as a whole, where policy design and implementation are shared with Member States, self-regulatory bodies, etc. In particular, while many of the key stakeholders operate at least in part beyond the reach of specific countries, their connections to those countries and the connections among different policy makers do create useful indirect policy traction.

At a more operational level, DG INFSO has a role to inform and support thematic DG's in their understanding of the emerging 'Internet of X' and how this affects their policy areas. Because the Internet is a privately-provided public good, and because the development of the Single market highlights its impacts at European level, the EC as a whole could take up this responsibility vis-à-vis the MS and exploit the EC's interdisciplinary technocratic nature (see Annex table 15. In addition, the development and application of connectivity-based monitoring, impact analysis and policy evaluation tools can be of considerable help. This has already been demonstrated in the policy arena by the application of social network analysis tools to RTD policies aimed at strengthening the European Research Area (ERA)[146] and by the successful use of connectivity-based structural parameters in labour economics[147].

Need for public leadership in setting the EC agenda and influencing global ICT/Internet policies

The EC is in a prime position to develop comprehensive strategies to address the challenges created by the financial crisis, or even to transform the opportunities for change provided by the crisis into feasible but ambitious strategies for Europe. Many of the most important potential benefits of enhanced connectivity are enhanced rather than diminished by the financial crisis. Many aspects of policy are likely to need adjustment to reflect changed possibilities for intervention and changing objectives, and connectivity policy is no exception. Moreover, the financial crisis is rooted in an increasingly connected financial system, giving connectivity policy a more central role in many policy agendas than it enjoyed in calmer times.

An important element in such a strategy could be the investment in high bandwidth infrastructure (as discussed above) and linkages across borders. Especially the latter is a key domain for the EC to mediate/facilitate. The EC can identify and collect information on the blind spots and the critical network linkages that need to be established.

As the Internet of X will be largely global, policies and ambitions should reflect this. The EU has been at the forefront of mobile technology in the past and has set global standards for data protection and has championed the use of open standards and fought against SMP by the key suppliers of ICT. In international fora like the WTO, WIPO, ITU, Internet governance institutions etc, the EU (still) has an opportunity to influence the value setting of these global phenomena. However, influence is rapidly shifting to new economic powers in Asia.

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[146] Wagner *et. al.* (2005).

[147] E.g. Corbo *et. al.* (2006, Calvó-Armengol (2004 and 2006), Calvó-Armengol and Jackson (2004), and Calvó-Armengol and Zenou (2005).

4.2.5 Instruments

The biggest legal/governance challenge is how to regulate/control networks effectively, and the traffic that flows through them, especially where these cross borders and jurisdictions. The question of how to manage the extension of governance to the cloud[148], and the general issue of how responsibility can be divided and the legal structures of contract, consumer protection, tort and even criminal law, can be adjusted to deal with ever-greater connectivity. ISP liability is part of this, but so are the concepts of informed and presumed consent. Others, which need further research than this report can provide may be found in technology itself. The use of technology as a complement of traditional policy tools like regulation, may hold promise for ensuring public interests where self-regulations is too weak and regulation cannot be enforced or is too inflexible and slow.

Multi-stakeholder networks and governance principles

More than technology per se, market and governance factors influence the development of technology trends and their socio-economic impacts. Early technology lock-in and network externalities – where they risk having a negative impact on technology development and innovation - must be identified and responded to through policies like: market regulation, spectrum allocation, subsidies and awareness-raising of alternative technologies. Through the creation or coordination of multi-stakeholder platforms and networks, and by applying multi-stakeholder governance principles, the EC can help to encourage efficient competition among technologies and discourage inefficiently-high incompatibility. These would be enabling the adoption of common standards and market wide approaches to public policy concerns (e.g. RFID network, dealing with standards, privacy and public awareness). There are obvious tensions between competition to provide a common platform vs. the advantages of specialisation, and more generally between competitive and regulatory governance. The challenge is to intervene in a way that replaces inflexible 'black-letter' prescriptions with mechanisms that help identify the best approach and engage the efforts of those best-placed to help it.

Technology as a complement of traditional policy tools

As already indicated in the section on privacy, the use of technology as a complement of traditional policy tools like regulation may hold promise for ensuring public interests where self-regulations is too weak and regulation cannot be enforced or is too inflexible and slow. Examples can be found along the whole policy development chain: citizen input through web 2.0 tools like Facebook; privacy enhancing technologies to empower the data subject; DRM (including watermarks, digital finger prints, etc) to enforce or replace traditional IPR, monitoring of behaviour and compliance, and also impact of policies in real time.

Supporting 'self-correcting' market mechanisms

Where possible policy solutions should work with the grain of the market, exploiting and supporting 'self-correcting' market mechanisms (Quality of Service/Net Neutrality, spectrum trading, etc.). These often need to be backed up with the threat of traditional regulatory intervention. The financial crisis has discredited self- and co-regulatory mechanisms. However, in the virtual world of the 'Internet of X' traditional regulation will

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[148] http://news.bbc.co.uk/1/hi/technology/7695624.stm

have very limited traction and will be difficult to enforce. Therefore the EC should further analyse how best to structure self-regulation, what the risks are and how to overcome these.

Better and more strategic use of procurement

Procurement – it is by now a commonplace that demand-pull is as important as supply-push in promoting innovation-led growth. This is particularly true in relation to the Internet of X; from its earliest beginnings in DARPANET to the large-scale public deployments leading the development and exploitation of e-identity technologies, the public sector has not only 'primed the pump' of Internet development but has strongly contributed to timely take-off and to a path of development that serves public as well as private interests. However, despite this oft-repeated observation and the enormous (40%) contribution of public procurement to overall GDP, the contribution of public procurement in innovation remains modest and patchy.

Key challenges are: Public contracting officers are institutionally risk-averse; cross-border procurement still represents only about 15% of overall public procurement; standard contract forms actively inhibit innovative solutions; legal restrictions inhibit (or discourage) exchange of ideas between purchasers and suppliers in advance of tender specification; post-award negotiation and partnership are difficult in law and practice; and political exposure actively punishes 'failed' projects (especially when new suppliers are involved) and imitation or adaptation of innovations developed elsewhere.

Spectrum allocation as powerful ex ante tool

Spectrum allocation is an important (*ex ante*) policy instrument to support innovation, the introduction of new technology, and more competition. In part because traditional ex ante regulation and ex post control of the wireless domain is becoming increasingly difficult, and the wireless domain in itself is becoming an increasingly important feature of connectivity. The use of auctions has lead to mixed outcomes, as it remains difficult to balance different policy objectives (technical, economic, and societal). Much available spectrum is hoarded or left idle along spatial, temporal, frequency, and power lines as a result of strategic behaviour, inefficient technology development or deployment, and changes in industry structure (mergers, bankruptcies, acquisitions, etc), and neither regulatory nor market mechanisms (spectrum trading) are addressing the problem effectively. Inefficient capacity use remains, while poor policy coordination leads to a lack of integration of technical, economic (spectrum and competition) and societal (esp. repeater/switch sitting) policies.

Technological and administrative changes such as increased efficiency of spectrum use and release of former public and analogue television spectrum (digital dividend) promise greater spectrum availability, but the explosion of commercial and non-commercial (societal inclusion, emergency services, etc.) uses may outstrip these advances. Certainly, governments are challenged to find effective and practical allocation mechanisms[149]. The overall regulation of spectrum use is gradually moving from traditional command-and-control methods

[149] To take a simple example, the allocation of 2.6 GHz spectrum poses difficult technical and economic questions that require very complex auctions; at the same time, the need to reconcile (market-mediated) efficiency with a mix of societal and commercial objectives makes it difficult to rely wholly on auctions – emergency services, for example, cannot compete with commercial service providers, but have much greater need for pre-emptive or ensured access in times of need.

towards a combination of liberalised (market-based) regulation, societal regulation (e.g. by imposition of public service obligations) and 'regulatory withdrawal' (expansion of unlicensed use of specific frequencies and/or power levels as an electromagnetic 'commons.' This transition is complex; both the initial placement (and reallocation) of spectrum and secondary spectrum trading must respect a range of policy objectives and legal constraints, including the need to delineate suitable property rights and to balance the mechanisms involved[150].

Due to the trans-European (and multi-sector) nature of the consortia bidding for (and offering services over) spectrum, and the advantages of trans-European markets in hardware as well as interactive services, there are strong arguments for harmonisation (or at least coordination) of some aspects of spectrum policy. However, spectrum policy remains the domain of national regulatory agencies and looks likely to remain so for some time. However, the failure of the proposed European Telecommunications Agency does not mean that Commission policy cannot have relevant impacts. Standardisation or protocols, spectrum rights, hardware specifications, etc. can be as potent in relation to emerging technologies (e.g. WiMax and LTE) as they were in relation to the GMS standard of the prior generation), and the balance of broadband spectrum use between truly mobile and 'simply' wireless uses can be influenced by leadership of European bodies and to the timing and extent of new developments. Thus the EC can play a vital coordinating and supportive role, not least by sharing good practice, collecting and analysing information and increasing awareness about spectrum allocation methods and other aspects of the efficient spectrum use and management[151].

4.3 Summary

This chapter has taken the inputs from all previous chapters to enable the identification of policies to deal with the uncertain future challenges of the Internet of X. These challenges may require policy interventions by governments (European Commission, Member States, or other) or other actors like business (ISPs, soft- and hardware producers, etc) and civil society (consumer organisations, advocacy groups, individuals, etc). Chapter 6 provides a framework for future policy relating to the Internet of X. Before describing what could be done in the future to deal with the connectivity challenges, the next chapter will provide a brief comparison with policy frameworks that are currently in place or being developed in

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[150] For instance, the initial placement of rights can only succeed if it attracts wide and sincere participation by a representative sample of potential users – but the possibility of secondary trading may discourage potential bidders (who may expect lower prices in the less-frenzied atmosphere of the aftermarket) or encourage insincere participation by players wishing to 'corner' the secondary market or impose costs on rivals.

[151] Note that this is *not* limited to regulation and standardisation; much of the tension and uncertainty surrounding the development of the next generation of wireless broadband stems from the very different maturities of the main competing technologies (e.g. WiMax and LTE). For reasons discussed earlier, unless they compete on relatively even terms, lock-in is highly likely; one technology will be used for many purposes, in which case there is no guarantee that the 'right' technology will prevail. On the other hand, if development support was used to 'level the playing field' there is a greater chance of: ensuring that, if there is a single winner, it is efficient; producing a 'stable diversity' of technology standards (if that is efficient); and providing incentives for interoperability that leaves users with the flexibility to adjust their connectivity as their needs evolve.

Japan, Canada, US and South Korea. Against this backdrop we then recommend certain policy actions to the European Commission, DG INFSO in particular.

CHAPTER 5 International policy comparison: US, Japan, Canada, and South Korea

Before recommending policy actions (Chapter 6), this chapter will briefly review the ongoing policy developments in other regions of the world. It should help the main actors in Europe understand what the current policy thinking is like and how Europe may interact with these developments. Moreover, as the Internet of X is expected to be a globally integrated phenomenon the actions of other nations and regions will impact its development and limit, expand or change the range of policy options that the European Commission and EU Member States have.

5.1 EU context

The Bled Declaration 2008 recognises an urgent necessity to redesign the Internet to meet Europe's societal and commercial ambitions. Bled emphasises the need to foster favourable conditions through coordinated actions and commits key European stakeholders (such as the European Technology platforms) to jointly develop the future internet.

Bled also commits stakeholders to raise awareness of the economic, policy and regulatory issues as identified by the European Future Internet Assembly, the UN Internet Governance Forum, the OECD and the European regulatory frameworks and to contribute to the definition of European positions within global forums and arenas.

The Communication on future networks and the internet (COM(2008) 894)[152] serves as a "preparatory step towards the internet of the future […]". The Communication recognises the important role of future networks and the internet in shaping our societies and in driving forward European competitiveness and welfare. It identifies three key ambitions in this area:

- Keep the internet economy open, notably to innovative business models. It will require a continuation and reinforcement of current pre-competitive regulation of e-communication markets and appropriate consumer safeguards.
- Stimulate investment in high-speed networks to meet future demands, development of future internet architecture and governance model, and better availability of spectrum to facilitate take-up of wireless services.

[152] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; {SEC(2008)2507; SEC(2008)2516}, September 2008.

- Ensure security and privacy of future networks and the internet and to guarantee that the internet of the future will be easy and accessible, safe and ensures the privacy of citizens.

In order to put the ambitions of the European Commission into an international context, in this chapter we review the future policy strategies of four countries: Japan, South Korea, Canada and the US. We are interested in particular in the time frame 2010-2020. In addition to the country reviews we discuss the ICT strategy of the OECD (as it is set out in the Seoul Declaration).

The countries that are reviewed in this chapter have been selected based on the terms of reference of the tender for this project, representing as they do exemplars in forward looking ICT investment and policymaking. The reviews are mainly based on a document review and key informant interviews.[153] The chapter is organised as follows: We first describe how far strategy development has progressed in the different countries. We then discuss whether (at this point in time) there are similarities/differences in the objectives and ambitions of the different strategies. Subsequently, the leadership of the strategies is discussed – before we turn to a short summary of what is known about each strategy.

5.2 International ICT strategies – Where are we?

The first thing to note about future ICT strategies in Japan, South Korea, Canada and the US, is that they are still very much works in progress:

Highlights from **US**

Lack of comprehensive ICT policy, but:

- The Recovery Act, including $7.2 billion FCC plan for national broadband, due in February 2010
- Appointed the first ever Federal Chief Information Officer
- Future ambitions in the ICT field is in the context of the development of a new generation network - Global Environment for Networking Innovations (GENI). Geni's ambitions:
    - Making the future internet secure
    - Ensuring adequate levels of availability
    - Providing right economic incentives
    - Making it more user-friendly
    - Future internet must enable and encourage
    - Mobility and universal connectivity
    - Availability of information
    - Sensor-based network
    - Social concerns such as privacy, accountability freedom of action and predictable shared civil space.
    - Seamless integration

- The Japanese government is currently conducting a major foresight exercise to develop its ICT strategy for 2025. The results of this exercise are expected to come out towards the end of this year.
- The Korean government does not have an explicit 2020 vision – neither are we aware of any work in this direction.
- In Canada there is little discussion of an ICT strategy beyond the year 2010. In fact, several sources criticise the Canadian government for its lack of ambition to develop a longer-term ICT strategy.
- In the US, much is up in the air given the transition to a new administration.

[153] We would like to thank those interviewed, All errors remain our own ones.

The OECD is an exception in this regard. In 2008 39 countries and the European Community adopted the Seoul Declaration for the Future of the Internet Economy. The declaration outlines the basic principles that will guide further development of the Internet Economy. It stresses the vital role that Internet and ICT technologies can play to tackle new challenges such as an ageing population, environmental and energy concerns, the scarcity of raw materials, globalisation and regional imbalances.

Having said this, there is indication of future aspirations in the ICT field in the four countries:

- Korea has a 3-year - 5-year 'implementation' plan.
- Canada, had its telecommunications policy framework reviewed by Industry Canada which recommended that Canada should "modernize its strategy to ensure that Canada has a strong, internationally competitive telecommunications industry that delivers world-class services for the economic and social benefit of all Canadians."
- Japan and the US are working on a new networking and distributed systems architecture that is meant to revolutionise computing. In the US this is referred to as Global Environment for Networking Innovations (GENI) – which is supported by the National Science Foundation. In Japan the project is referred to as New Generation Network (as opposed to Next Generation Network which typically refers merely to the migration from IPv4 to IPv6).

> Highlights from **Japan**
>
> Currently conducting a major foresight exercise to develop its ICT strategy for 2025
> New Generation Network (NWGN) project; as a clean slate network architecture, with protocols that may not be IP-based. Current framework of Japan's ICT strategy 2006-2010
>
> - IT to resolve issues in health and the environment; live safely and securely; meaningful activities by government, business, and individuals
> - Creation of an IT society
> - Safe use of IT
> - Human resource development
> - International competitiveness of Japan
> - Contributions to other Asian countries

5.3 What are the main ambitions?

In terms of the objectives and ambitions underlying this early thinking, we find a broad consensus around the idea of an emergent ubiquitous network society – where anyone can use the net at anytime from anywhere for any purpose.[154]

However, it is important to note that neither the countries that were reviewed nor the OECD aspired for the ubiquitous network society for its own sake. Instead, it is generally considered as an important step towards achieving a number of societal objectives. In Japan, for example, it is hoped that the ubiquitous network society will contribute towards the realisation of economic ('become the most advanced market'), social ('improve and reform

[154] As an example, the Korean 'implementation plan' plan states: "The successful implementation of [this strategy] will result in ubiquitous technologies being applied to every sector of society […]". Similar statements can be found for the other countries (and the OECD).

lifestyles') environmental ('contribute to environmental/energy issues') and safety ('achieve a safe and secure society') aspirations.

Table 11 lists the main aspirations linked to the ubiquitous network society:

Table 11: Aspirations linked to the ubiquitous network society

	Economic	Social	Environmental	Safety	Other
	Become most advanced markets.	Improve and reform lifestyles from the perspective of the general public; close digital divide;	Contribute to environmental/energy issues.	Realise a safe and secure society.	A Japan that all can be proud of; maintaining status as cutting edge IT nation;
	Improve national competitiveness; higher national income.	Improvements in the quality of public life;	Ecological industrial infrastructure; regenerative economy	Realise a secure and safe social environment	Become an intelligent country;
	Improved Productivity growth; place Canada at global and regional supply chains.	Improve delivery of public services (such as health);		Reduce cyber-crime and threats to privacy	
	Improve US competitiveness and economic growth;	Smarter, healthier and more satisfactory network;			
	Promote economic growth; address regional imbalances;	Help tackle problems associated with ageing population; increase e-inclusion;	Help tackle environmental problems.	Reduce cyber-crime; protect critical infrastructures;	

While the emphasis in the documents on future ICT strategies is on the positive potential impacts of a ubiquitous network society – whether economic, social, environmental or safety-related in nature – some of the documents also discuss potential negative consequences from such a society. The Korean 'implementation plan', for example, warns from problems of:

- Increased verbal violence and defamation in cyberspace;
- Increased online addiction (with people finding it difficult controlling the amount of time they spend online); and
- Increased energy consumption and carbon emission on part of the IT sector (raising environmental concerns).

Other potential threats arising from a ubiquitous network society that are mentioned include:

- Concerns of privacy, accountability, freedom of action and shared civil space. (US; OECD)
- Increased circulation of harmful information – in particular in the context of children using ICTs. (Canada; OECD)
- Increased undermining of economic incentive structures through online piracy and/or unclear intellectual property rights. (Japan; US; OECD)

> Highlights from **Canada**
> From: Industry Canada's Telecommunications Policy Review Panel.
>
> ICT services, applications and skills seen as crucial fro Canada's competitive position
> The recommendations can be organised around five themes:
> - Strengthen ICT Adoption by Canadian Businesses
> - Strengthen ICT Adoption by Government
> - Strengthen general ICT Adoption skills
> - Strengthen ICT R&D
> - Promote Security, Confidence and trust in an Online Environment.
>
> The Policy Review Panel makes the case for an increased awareness of the risks and vulnerability associated with ICT adoption. These include in particular:
> - Risks threats to privacy,
> - Safety, reliability and security of networks,
> - Cybercrimes and
> - Illegal content.

In addition, as is discussed in more detail in the case studies (Appendix D:), even though all the strategies (or antecedents thereof) agree, by and large, on the main objectives and ambitions of a future ICT strategy, there are differences between the cases in how these objectives and ambitions are best to be achieved. The Canadian plan (as suggested by the Review Panel), for example, puts much emphasis on the role of market forces in achieving the objectives and ambitions. The Japanese and Korean plans, on the other hand envisage a significant planning and regulating role for the government.

Similarly, while South Korea, Canada and the OECD focus on the upgrade of the existing net architecture (from IPv4 to IPv6) as a way to deal with the problem of running out of IP addresses as more and more electronic appliances are connected to the internet and so to achieve the ubiquitous network society, Japan and the US work on a completely new generation of networks – which is the New Generation Network in Japan and the GENI project in the US – to achieve this end.

5.4 Who is in charge?

The importance of ICT policy in the different countries is reflected in the leadership. In Japan the IT Strategic Headquarters are in charge of the national informatisation plans and projects. The Headquarters are chaired by the Prime Minister. In Korea it is the Information Promotion Committee (IPC, http://www.ipc.go.kr) that is in charge of facilitating the smooth implementation of reforms. The IPC is chaired by the Prime Minister and comprises 25 members, including all Cabinet Ministers.

The Policy Review Panel of Canada suggests that an ICT strategy in Canada should be initiated at the highest levels of government. To provide the leadership that is necessary to promote effective national engagement, the Panel recommends that the Prime Minister should mandate the Minister of Industry with the lead responsibility for developing and implementing a national ICT strategy.

In the US, the President appointed the first ever Federal Chief Information Officer to provide management and oversight over federal IT spending and nominated the first ever Federal Chief Technology Officer to provide vision strategy and direction for using technology to bring innovation to the American economy. In addition, only recently President Obama has created the new position of a National Cyber Security Adviser, who – as the Chief Information Officer and Chief Technology Officer – reports directly into him. The Cyber Security Adviser has broad authority to develop a strategy to protect the US government-run and private computer networks.

These high level positions/committees are typically supported by a number of implementation bodies: In Japan, responsibility for the implementation of the ICT strategy lies with the relevant Ministries. In case of the New Generation Network, the development and coordination between industry, academia, and government lies with the National Institute of Information and Communication Technology (NICT). NICT is a national research institute in the information and communication field that conducts its own technical research and contributes the national polices in the field.

Highlights from **South Korea**

u-Korea Master Plan (March 2006); listing regulation on informatisation divided broadly into five categories:

1. building the infrastructure
2. revitalization of information services,
3. advancing the ICT industry
4. creating an environment for fair use of knowledge and information
5. preventing all sorts of malfunctions and adverse effects of informatisation,

Three ambitions of the u-Korea Master Plan

1. Infrastructure Ambitions
   - Broadband Convergence Network (BcN),
   - Ubiquitous Sensor Network(USN)
   - Promote the spread of Internet Protocol version 6 (IPv6) (NIA 2007a).
2. Software Ambitions
   - increasing demand for open source software (OSS)
   - through large-scale public projects
3. 'Dealing with Challenges' Ambitions
   - verbal violence and defamation
   - online addiction
   - Green IT

In Korea, since 2008, responsibility for implementing national informatisation and the ICT industry lies with two newly created ministries, the Ministry of Public Administration and Security (MOPAS, http://www.mopas.go.kr) and the Ministry of Knowledge Economy (MKE, http://www.mke.go.kr). The MOPAS integrates the functions of the Ministry of Government Administration and Home Affairs (MOGAHA) and the former Ministry of Postal Services (MIC). It has organised the Informatisation Strategy Office for the promotion of e-government and national informatisation.

The Canadian Policy Review Panel suggests that, to the extent that the development and implementation of a national ICT strategy requires support in issue identification, policy research and analysis, consultation, coordination, implementation and evaluation, the Prime Minister should mandate the Minister of Industry to establish a National ICT Adoption Centre within Industry Canada. In the US under new leadership, with some telecom background, the Federal Trade Commission (FTC) is likely try to become more active, under the umbrella of consumer protection and competition policy.

- Under the umbrella of consumer protection, the Division of Privacy and Identity Protection, the newest of the of the Bureau's divisions oversees issues related to consumer privacy, credit reporting, identify theft and information security.
- Under the umbrella of competition policy, the competition in the technology marketplace division promotes competition in technology industries (like computers, software, communications, and biotechnology) as the best way to reduce costs, encourage innovation, and expand choices for consumers.

A big question is what will happen at both the National Telecom and Information Administration (NTIA, www.ntia.doc.gov), which is being revitalised, and Federal Communications Commission (FCC, www.fcc.gov), under new leadership. NTIA has in the past promoted inclusiveness, in a different (traditional telecom policy) way, so has FCC.

5.5 Summary remarks

In this chapter we have summarised from the case studies in Appendix D our review of the ICT strategies of four countries and that of the OECD (as described in the Seoul Declaration). The main findings can be summarised as follows:

- The development of a future ICT strategy is still very much work in progress in all countries. With the exception of the OECD there is no fully developed ICT strategy for the time frame 2010-2020.
- Early thinking about a future ICT strategy seems to revolve in all cases around the idea of a ubiquitous network society. Particular emphasis is given to the positive societal impact associated with such a society – but also potential threats (such as increased internet addiction or concerns of privacy, accountability and freedom of action) are articulated.
- In terms of leadership ICT strategy development and implementation are ranked highly on the agenda of most countries – as is reflected in the engagement at highest political level in these countries.
- Despite the agreement on the objectives and ambitions of a future ICT strategy (in the early thinking) there are significant differences between the different countries (and the OECD) how these are best to be achieved. These differences range from differences in the role of government to differences in further technical development.

The emerging Internet of X is a global phenomenon. Thus any EU policies should take account what is happening in the rest of the world and how its own policies may affect other regions. The next and final chapter presents a policy framework for the EU.

CHAPTER 6 Recommendations: A policy framework for the Internet of X

In recommending a policy framework, this final chapter draws on the scenario workshop results, the international policy comparisons and a briefing paper for DG Information Society and Media on 'Connectivity Challenges'. In this section, we:

- Describe the rational and underlying principles of a policy framework
- Discuss the basic argument for the policy framework;
- Provide an outline of the overall structure of the policy framework
- Present a vision of the overarching policy objectives and connectivity challenges;
- Outline the specific policies that will populate the framework; and
- Indicate how the framework could be applied for policy development, coordination and assessment both within DG INFSO and Media and across the Commission.

6.1 Rationale and principles of the policy framework

There are several powerful reasons to formulate policy in relation to the connectivity challenges raised by the Internet of X in an explicit framework. Such a framework helps to make explicit the 'intervention logic' by which policies at differing levels, and with differing objectives, tools and addressees, can interact to shape the evolution of the future network, and conversely provide a structure whereby the implications of network evolution for different policy domains can be taken into account. The framework has three other specific advantages:

- It is derived from the well-known Logical Framework Methodology, and is therefore consistent with both ex ante and ex post policy evaluation;
- It can be applied at various levels, and therefore 'rolled up' or 'drilled down' to add detail or facilitate coordination; and
- It is consistent with the concept of 'policy chapeaux' applied in i2010 and increasingly used to characterise the collection of activities being carried out under the "Future Internet" rubric.

The complexity of the future network and of the technical, economic and societal systems that will rely on the connectivity it provides argues strongly for the advantages of a policy framework over specific policy recommendations. This complexity makes prediction and control difficult. Even the medium-term future holds many possibilities, but these are not evenly distributed – critical uncertainties along the way will produce sharply different impacts, affect the behaviour of third parties and therefore the scope for policy intervention. In such a system, unintended consequences are guaranteed, and guaranteed to drive new requirements for policy. A logical framework is needed to guide monitoring, policy assessment and policy coordination. At the same time, it does not provide a wholly reliable guide to policy; the structure of the Internet of X is sufficiently entangled with economic, societal, etc. structures that a hierarchical picture[155] cannot accurately capture the richness of the system. Thus the framework is intended precisely as a framing of a policy approach – a way of determining which aspects are relevant and communicating the basis for current and future decisions.

Four important aspects of the system necessitate such a flexible approach:

- The structure of connectivity – stakeholders' actions (including policy) affect many parties indirectly, and trigger responses that flow through their connections in turn. These extended impact mechanisms are hard to describe, model and control; moreover, the net effect of policy depends as much on dynamics (who reacts first) as on how their interests are affected.
- Openness – because the boundaries of the effective groups in the Internet of X do not coincide with jurisdictional, market, technology, etc. boundaries, the actions and reactions of stakeholders are likely to neglect or take inconsistent account of spillovers, or to overestimate the degree of control.
- Emergence and synchronicity – like all complex systems, the Internet of X produces emergence - "the arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems[156]." Almost by definition, complexity arises from the interconnectedness of the system, and is often irreducible - it cannot be predicted or deduced from the component parts. These emergent properties (which include policy-relevant outcomes such as inclusion, competition, trust, etc.) can be effectively synchronised, in that changes can occur simultaneously across a wide area without any obvious diffusion. The resulting impact may therefore owe more to choosing the right time and working with other trends than to a volumetric intervention sufficient on its own to create critical mass.
- Lock-in[157] – many of the most important aspects of the Internet of X depend on interoperability and convention. As a result, technology choices, market and societal structures and norms of behaviour can be progressively reinforced to such an extent that they resist change even in the face of superior alternatives. By the same token, superior choices whose collective benefits take time to materialise may be sustained against

[155] Where micro-level actions can be rolled up to predict policy outcomes at the meso (e.g. sectoral or regional) and macro (e.g. national or European) levels, or where it is possible to drill down from macro- and meso-level data to micro-level assessments of policy implementation and compliance.

[156] Corning (2002)

[157] See Cave (2009)

inferior, but more attractive in the short term, alternatives by cohesion. This possibility may make policy difficult. To take an example, consider policy aimed at restraining or overcoming the tendency of Internet markets to tip into monopoly. Anticompetitive behaviour can't always be detected or prohibited *ex ante*, but *ex post* remedies (after lock-in has occurred) may be too late, and there may be no counterfactual evidence to demonstrate that alternatives are viable if lock-in is widespread. Moreover, many of the specific activities that firms might use for predatory purposes (e.g. proprietary standards, low "penetration" pricing, etc.) are also essential in order to attract complementary content and services to Internet platforms capable of providing effective competition. Therefore, conventional antitrust policy may be less effective than consumer protection policy or supporting activities that enable users to coordinate moves to superior entrants, and participatory self-regulation may be more effective than IPR policy in deterring or overturning "stealth patents" in public standards[158].

These considerations lead to four overarching principles for policy formulation in relation to the Internet of X.

- Appropriate scope: to date, Europe and most other major public sector actors have not tried extensively to regulate the Internet. As its spread an importance increase, this may no longer be possible, especially as other regulated activities 'escape' on-line and new policy concerns emerge. But alternatives to regulation, the consequences for other policies and objectives and the need for coordination should be considered early in the policy process.
- Humility – many of the drivers for policy arise from the considered and strategic actions of other major Internet of X stakeholders. Therefore, it is appropriate to change from the traditional perspective of the policy maker as a controlling designer of games for others to play to a more effective and appropriate view of policy makers as one among the players in a self-organising game, This allows both the advantages and disadvantages of first-mover precommittment to be evaluated against a more reactive alternative.
- Imagination – the emergence of new structures, players and interests challenges customary policy processes, including the compartmentalised approach common between different departments and layers of government. The network perspective permits policy makers to take cross-impacts into account and to think "outside the box" of such foregone conclusions as the idea that if something is good (e.g. trust, competition, inclusion, connectivity, etc.) then more is necessarily better; and
- Multi-stakeholder and/or partnership working –effective and appropriate policy should take into account the information, objectives and powers of action of all key stakeholders; where the rules of the game have changed, it may therefore be necessary to redraw the boundaries of responsibility and power[159].

[158] Latimer and Ablin (2000)

[159] This approach is increasingly adopted in such areas as societal regulation of content, Internet governance, etc.

6.2 Basis for the framework

In practice, the framework would be implemented by an explicit description of the design of policy. This is followed by an intervention logic identifying the specific levels at which:

i) the need and justification for policy intervention is assessed,

ii) policy is discussed and specified

iii) agreed initiatives are implemented,

iv) outputs and outcomes are developed, strengthened and assessed

v) broader impacts and sustainability effects are measured and used to adjust activities

vi) overall impacts are subjected to ex post assessment to identify successes, failures and changed conditions.

As part of policy design, associated with each level are explicit 'success criteria,' relevant data, indicators and evaluative methodologies, and specific risk factors that might explain measured performance and which may provide leading indicators of useful changes.

The range of policies is much greater than is conventional in logical framework evaluations, but the principles of 'rolling up' specific frameworks into an overarching perspective are straightforward, once the purpose of this aggregation is clarified. Moreover, the policy context of the Internet of X is joined up in significant ways. The Internet(s) involved underpin almost every sphere of public and private-sector interaction. Two immediate implications of this recognition are:

- Connectivity and other characteristics of the Internet of X can be viewed as objectives in themselves or as enablers of progress in other areas – in other words, they may be valued directly or indirectly
- Specific indicators and measurements can be used directly or as indirect indicators of progress in other areas.

Therefore, they affect (and are affected by) a wide range of policy domains and objectives. In consequence, the sum total of these policies may result in synergies, gaps, duplication or even conflicts. The explicit recognition of these overlaps and interactions in the framework can have the effect of encouraging conversations and coordination both among public policy actors and between them and other (e.g. private-sector) stakeholders.

The utility of the framework is to provide an organising frame for mapping relations between policies, organising evidence, establishing policy priorities and supporting monitoring, evaluation and adjustment. Specifically, it must: support problem identification and assessment; inform the division of roles and responsibilities; identify and draw attention to externalities (e.g. where policy in one domain affects the objectives or instruments of another) and guide the implementation (including coordination) of policies.

The construction of the logical framework begins with the mapping of objectives against tools; in order to identify the component logical frameworks corresponding to coherent 'modules' of Internet of X policy, and at the same time to record common objectives and policies for use in combining the component policies. This can be visualised with a matrix framework of tools against objectives, to be fleshed out at different levels. In this document, we concentrate on the European level. The following matrix shows a suggestive candidate – there are obviously more rows and columns that can be usefully summarised in a Table, so the framework should be seen as a template for the following discussion of objectives and policies and as a way to relate the policy recommendations to each other.

We suggest dividing objectives and tools in those that are common or overarching (and are thus present in every specific instance of the mapping table) and those that are specific to the area under consideration. This corresponds to the conventional distinction between strategic and instrumental objectives. In case of the tools, it separates policy frameworks and overall strategies from specific actions. In this (high-level) example, we consider some policy actions that might facilitate business process outsourcing by means of greater infrastructure connectivity, Utility Computing and an Intelligent Web providing enhanced security, integrity and Quality of Service functionality. Ideally, the matrix would be used as the basis for discussion with the cells inside the matrix containing specific policies around which to build the logical framework.

Table 12: Exemplary tool/policy concordance

Objectives		Common			Specific	
Tools		Jobs	Growth	Inclusion	Competition	eGovernment
Common	Policy chapeaux: join education, finance, competition, investment, RTD and social policies	Encourage sustainable, rewarding employment, support transition to 'comparative advantage' jobs	Reduce costs of European producers on world markets, enhance profit retention, reinvestment	Strengthen access to job opportunities and remote working, encourage outsourcing of some social service to cut costs, raise quality	Apply SMP tests to non-European suppliers as well; ensure regulation maintains competition at Internet layers (structural separation)	Limit outsourcing of key services, promote cross-border eService procurement
	ICT strategies: promote innovation, investment, infrastructure extension, service uptake	Promote remote working through structural policies, improve ICT skills distribution	Creation of infrastructures supporting regional hubs and clusters; improved access to ICT investment and innovation	Extended Universal Service, accessibility components as separate initiatives or bundled obligations	Limit 'tipping' in market power and IPR control; require open access, data -sharing	Pre-competitive procurement, lead markets initiatives
Specific	RTD support	Multistakeholder consortia, socioeconomic research (e.g. on labour market impacts), technologies to support federated identity, other aspects of	Research on growth modelling, accounting; continuous support for development, deployment, RTD contests, portfolios	Accessibility research; varied consortium composition, roles; mobility between countries as well as research-industry.	Revise IPR conditions to bring in legacy IPR, encourage wider exploitation	Support technologies for PEGS delivery and assessment

Objectives		Common			Specific	
Tools		Jobs	Growth	Inclusion	Competition	eGovernment
		remote work security				
	Telecom regulation	Regulation of entry, spectrum allocation and net neutrality	Spectrum trading, regulation of cloud computing as utility; unlicensed spectrum	Universal service, community network/public service access, pricing.	Spectrum trading, settlement arrangements	Infrastructure access, monitoring and control; publicly-controlled spectrum
	Standardisation	Open standards for data exchange	Open standards, SME participation in standards bodies	Standards for accessibility, lay participation in standards bodies	Controlled openness, arrangements for standards updating, 'virtual enterprise' standards	Mandated use of open standard ICT; participation in service standards
	Investment	Regional broadband infrastructures	Regional broadband infrastructures	Regional broadband infrastructures; access hardware	SME, regional support; multiple 'pipes', public alternative infrastructures	Pre-competitive procurement, design contests, multi-sourcing

Once this mapping has been completed, the next step is to construct specific logframes – this step is routine, and is therefore omitted from this discussion. We now turn to a more nuanced discussion of the policy objectives and associated challenges. This is not meant to pre-empt the richer discussion arising from the broader Future Internet initiative, but rather collects some reflections on the *nature* of the complex of policy objective formulation in relation to the Internet of X and their implications for the policy framework.

6.3 Overarching Objectives

The general objectives of any European policy would be to add value up and beyond national policies, by exploiting scale, reducing fragmentation, etc. European-level policy relating to the Internet of X must therefore be consistent with strategic objectives as described in the Lisbon Agenda, detailed in e.g. i2010 and applied to the Internet domain – in essence, to ensure that the Internet develops and is exploited in ways that promote European competitiveness and well being for this and future generations whilst safeguarding core European values in the global Internet space. It must also be consistent with Treaty Principles, including proportionality and subsidiarity but also taking into account important objectives of safety, security justice and civil liberties. Finally, it must build on and harmonise the collective impact and implementation of existing policy, regulatory and related public action initiatives both at European level and across the Member States (and, for some activities, European regions).

This is a difficult task in any 'joined-up' policy area; it is particularly challenging in relation to the Internet, many of the key players and aspects arise beyond Europe's borders, where change is rapid and often discontinuous or disruptive and where the information needed to track progress and adjust or explain policy, while abundant, is complex, fragmented and not always consistent or of uniform coverage and quality. Therefore, we feel it is useful to provide a framework that can be flexibly applied, along with a 'policy ethos' that can improve understanding and engagement by the many players involved.

The strategic policy challenge is to:

- develop *responsive* and *sustainable* strategies to ensure European leadership in the shaping of the future Internet' and
- make all efforts to create a 'ubiquitous internet society', which suits the needs of businesses and citizens in Europe; which
- supports global safety, stability and welfare.

This should be based on a clear understanding of the changing socio-economic realities caused in part by increased connectivity and access, ubiquitous computing and intelligence of the web, as well as human-computer convergence, and to manage this effectively all across the policy landscape - much of which has been discussed in this report.

At this high-level, despite the complexities of implementation, the policy objectives seem reasonably straightforward and consistent with those of other policy domains. But this simplicity is advantageous only to the degree that it allows the different stakeholders to 'agree to disagree' or to avoid unproductive arguments about specific details. Therefore, it is necessary to begin by recognising that the Internet of X is – from the policy perspective – an objective or end in itself and simultaneously a means of reaching other objectives. The Internet as addressed by policy is:

- A set of concrete (and technically describable) physical infrastructures and equipment, services (in the ICT sense) and applications;
- The use of these resources to provide end-user and interim services (in the non-technical sense) to civil society, public sector and private sector actors;
- The transactions (including communication, commerce and joint working) taking place over the 'physical' Internet by applying these services;
- The (patterns of) linkage, interaction and shared interests, identity and values among individuals, groups and institutions arising from the provision and use of these services;
- The potential of the network to develop further and respond to experience, new challenges and developing technologies, markets and societal forms; and
- The incentives and obstacles to innovation, growth and (economic, technical, personal and societal) development created by the above.

Thus the Internet of X:

- Is affected by a range of policies – each with its own objectives, tools, limitations and constituency;
- Produces a wide range of impacts in various domains (e.g. technical, economic, societal, environmental) whose measurement may be complex, difficult or hard to interpret or attribute;
- Creates these impacts through a changing mix of multiple channels involving various combinations of public, civil society and private sector actors; and
- Is subject to uncertainty at every step.

These factors taken together determine the nature and use of a policy framework. The use of Logical Frameworks, is dictated by the need to explicitly describe possible mechanisms by which impacts are produced, identify appropriate criteria and associated data, indicators and measurement methods and to take appropriate account of uncertainties and key assumptions dictates. The frameworks are conventionally used for policy evaluation[160]; we simply note that in this case they are necessary for policy formulation and discourse as well.

The need to take into account policies at other levels of government, key actions by outside stakeholders[161] and the interaction of policies pursued by different agencies of government reinforces the case for logical frameworks. Of course, these other policies do not 'belong to' some embracing Future Internet policy – rather, the Internet of X provides a common basis for reference in order that policies in other domains can easily and consistently take into account both their impacts on other policies and the contributions of those policies to their own objectives. Thus the collaborative or at least coordinated development of suitable logical frameworks (which we do not undertake here) is itself and important aspect of policy development, leading to joint action, the identification of duplication, overlaps, conflicts and gaps in policy and the exchange of relevant management and tracking information. To this end, the policy framework needs to identify the concrete challenges to be addressed (to which we now turn) and the who, what, when and how of associated policies (discussed below).

6.4 Understanding the 'Connectivity Challenges'

This report has discussed at length that the world we are moving towards is heavily influenced by ICT and now mostly dependent on the Internet. Governments will have to deal with new phenomena associated with connectivity and the complexity generated by (global) networks both as a new policy domain and in relation to almost every area of existing policy.

In particular, it is the *connectivity* implications of ICT that are rapidly becoming critical factors in most policy areas. Connectivity is as much an instrument to achieve socio-

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[160] Ranging from ex ante evaluation and Impact assessment through interim and final evaluation.

[161] Non-European governments, transnational actors and civil society and private sector actors.

economic benefits as a socio-economic objective in its own right. Connectivity is essential not only for delivery of the services necessary to individual and social welfare, but to engage citizens and empower them to take control of their own destinies. This is not a trivial matter of maximising infrastructure and minimising barriers to interoperability; connectivity provides access to both risks and opportunities and facilitates exploitation as well as mutually-improving interaction – what is needed is the right amount – and the right kind – of connectivity. Any post-12010 programme needs to have connectivity at its core; how it enables (or contributes to) policy objectives, what challenges there are to achieving desirable connectivity and how the Commission can act to remove barriers and stimulate developments to identify the right kinds and amount of connectivity, mitigate bad connectivity and enhance good connectivity.

Connectivity as a policy issue overleaps both national jurisdictions and formerly separate policy domains – this cross-linking can produce unintended perverse effects on policies in adjacent policy areas. It thus has increased the complexity of the policy challenge.

It is useful to distinguish three kinds of connectivity challenge:

6.4.1 **Challenges associated with connectivity *per se* (divided between technical and market and legal/political)**

Technical:

- Fostering the development and uptake of open standards and protocols in order to enable interoperability;
- Securing sufficient spectrum and other communication capacity and ensuring its equitable allocation and efficient utilisation in order to nurture innovation and growth and discourage anti-competitive behaviour;
- Modifying or replacing the end-to-end principle by possibly putting security and other 'public good' controls in the network and providing more definition to the boundaries of end-user and system control points;
- Preserving the openness and reachability of name and address space; managing different languages and the expected huge increase in numbers and types of name and IP address holders without locking in adverse effects of transitional shortages of addresses and names or distortions in the 'market for names;
- Unbundling or realigning governance responsibilities in order to adjust to the increasing importance of economic, political and cultural interests in domains (tools , stakeholders and institutions) that were once exclusively concerned with technical regulation (Internet governance, spectrum policy, equipment approval, etc.);
- Increase the sensitivity of technical measures and regulation to salient aspects of network structure or topology in order to maintain the beneficial aspects of connectivity as the online environment gets more complicated and numerous and as 'connectivity dominance' (linking power) becomes as important as technical dominance and market power;
- Dealing with 'bad' connectivity (spam, fraud, malware, manipulation of connections, access and services availability, etc); costs associated with bad

connectivity and potential to undermine (or make unattractive) certain types of usage.

Political/legal

- Optimising the contribution of connectivity to sustainability
- Failed IT projects, and the challenges presented by the current financial climate reduce incentives to support and invest in 'connectivity' initiatives
- Maintaining the global reach and functionality of connectivity; facilitating Europe wide (and global) solutions instead of national fragmentation
- Ensuring appropriate legal and regulatory conditions for cross-border and other connectivity; issues of liability, termination and settlement arrangements, regulatory burdens

Market

- Anti-competitive behaviour: dominant players excluding others and exercising power over other layers or points in the value chain; consequences of network externalities; vertical and/or collective dominance; control of key IPR, standards
- Limits to effectiveness of 'self-correcting' market mechanisms - net neutrality abuses or rules, impacts of spectrum trading, the 'wrong kind' of discrimination, quality of service shortfalls, 'crowding-out' or 'crowding-in' overpayment for spectrum, etc.
- Under-connection due to network externalities leading to inefficiency
- Failure to assess and price network public goods (connectivity) and bads (risks);
- Access to funding for infrastructure investment; difficulty to share cost over all users of the infrastructure; substantial financial entry barriers may prevent the deployment and maintenance of suitable connectivity; excessive leverage or risk-shifting may prevent profitable investments or encourage loss-making ventures
- Emergence and survival of suitable business models and alliance arrangements to fit specificities of new (rather than incumbent) technologies and services

6.4.2 Secondary challenges from the use of networks and communication services

- Over-connection in relation to responsibility; risk of accommodating too much 'best effort' activity leading to free riding; 'weakest link' issues of security and trust leading either to over-provision or opting-out; knock-on effects on extent, nature and sharing of innovation, profits and risks
- Business model development and ecology; facilitating connectivity that is suitable for the European context and supportive of (small) business, downstream and upstream aspects of emergence and survival of suitable business models and alliance arrangements
- Problems with the structure of connectivity at the economic and societal layers; low levels of cross-border commerce and effective business to consumer connectivity, too

much concentration of linking power or too much associative (like-with-like_ linking leading to technical, economic and societal segmentation if not stratification

- Privacy concerns; adjusting regulation, policies and tools to new 'information centred' economy and society, but ensuring the possibility to exploit the potential value of personal information whilst guarding trust and security
- Developing and testing technical alternatives to socioeconomic and legal regulation: like technical alternatives to human surveillance (e.g. deep packet inspection, automated DRM) and technically-enabled 'virtual' alternatives to real-world interactions
- Managing the increased political profile of technical regulations and standards; balancing different societal interests that are affected by technology
- Dealing with technology lock-ins; that bind customers to supplier, through switching costs and network externalities

6.4.3 Applying connectivity perspective to other policies

- Connectivity considerations arise both from Internet connectivity and from personal, market, etc. in other contexts. These affect all policy domains and 'soft connectivity' must thus be taken into account.
- With regard to the societal impacts of seemingly technical issues, examples are:
  - Growing personal and social dependency on connectivity and the Internet in particular as the Internet becomes ever more critical to our economies and lives.
  - Emerging service economy and the migration of jobs, as work becomes 'weightless' and location free, which can impact European competitiveness. (e.g. outsourcing can destroy (current) European jobs, make Europe's economy dependent on foreign labour; result in the reconfiguration of outsourced services away from European specificities; while on the other hand, it lowers labour costs for European businesses, encourages the migration of labour to jobs offering a more sustainable comparative advantage, provides both income and affinity to increasingly-wealthy and educated foreign populations shifting from suppliers (of labour) to customers, and breaks down insularity that inhibits the development of global entrepreneurial ambitions and opportunities.
  - Ageing population; supported as well as challenged by connectivity
- With regard to the lessons of Internet connectivity insights for other policy domains, examples are:
  - The technical trends and the importance of distinguishing network layers and flows, the choices made by network participants and associated concerns of privacy, integrity, etc. are increasingly applicable to other network industries, notably 'smart' electricity and transportation networks, but also global finance.
  - The concepts of good and bad connectivity, and the importance of network structures and dynamics, are directly applicable to a range of social issues such as education, health care, drug use and financial services

- The modelling in this report of the epidemiology of malware and other threats and of risk management behaviours in network environments, which borrowed from public health and animal disease policy analysis, has introduced network structure and 'rewiring' aspects that offer new insights and practical policy advice to those areas

6.5 Specific policies and policy areas

There are a few crucially important policies, in which the role of the Commission is evident that have an important impact on connectivity and other EU policy domains. These can be divided into different policy types as follows:

- Regulation:
  - Various specific types of *ex ante* and *ex post* regulation[162] e.g.: technical compliance, licensing and interference; spectrum allocation and use; competition regulation; telecommunications pricing; interconnection; content regulation; fair competition and merger regulation; consumer protection; privacy; digital signatures; databases; copyright; e-commerce; labour conditions, etc. It also includes coherent 'packages' of regulation, notably the electronic communication services regulatory framework. *Key challenges are to balance lightness of touch with credible effectiveness[163], to make appropriate tradeoffs between different perspectives (e.g. technical, economic and societal) on common issues and to prevent capture and/or foreclosure that distort markets and the development of the Internet.*
  - IPR regulation, can prove fair returns on (risky) inventive activity and [164]signals as to where ideas are best applied and which areas are most in need of further development. *Key challenges here are the one-size-fits-all nature of the most common forms of IPR protection, the potential for failure in the market for IPR, the possibility that market power in the market for innovation will spill over into markets for goods and services or vice versa and the possibility that predatory use of IPR or alternatives such as secrecy and strategic incompatibility may undercut the hoped-for benefits.*
- Standardisation – although standards are not enforced by European institutions, they are often strongly encouraged through official participation in standards

[162] These may be implemented at European level (through European Regulations or (more typically) at Member State level (through European Directives).

[163] Regulatory burdens must be minimised and fairly distributed if regulations are to be effective – regulation needs compliance and engagement by the regulated parties, especially when the latter have superior information about the issue at hand. Regulation must therefore take these 'outside' channels into account and may even need to work with or through them (co-regulation or delegated powers). Additionally, it must be recognised that regulations are fixed to jurisdictions while the regulated activities (in the Internet setting) are not.'

[164] Especially through licensing and other secondary IPR markets

bodies, inclusion in procurement and regulations[165] and support for standards development activities by beneficiaries of other forms of European policy support. *Key challenges[166] here are to maintain openness of standards (to avoid lending public support to proprietary standards), to balance the interoperability advantages of standardisation against the potential loss of diversity and inhibition of innovation and to ensure that standardisation enhances the innovativeness and competitiveness of the European economy[167].*

- RTD support – through the Framework research programme, and the European Research Institute, member State Research Councils and other national innovation system actors. It can contribute to the management of connectivity and other policy issues connected to the Internet of X in various ways; by commissioning directly applicable studies ranging from technology to socioeconomic research; by 'joining up' different disciplinary, national and community of interest actors (network structuring); by providing a flow of useful knowledge, human and social capital to development and deployment activities and by strengthening the European Research Area as an "attractor" to help articulate a European perspective on global policy problems, ensure that other policies are rigorously evidence based and attract needed investment and market opportunities. *Key challenges are to ensure the integration of European RTD support with other parts of the innovation system, to preserve the openness and 'generative' aspects of the project pursued, to engage the best researchers and ideas (especially for topics of public or societal interest) and to enhance the structuring impact, sustainability contributions and 'pull-through' to implementation of the RTD investment.*
- Development and deployment support – to convert inventions and other fruits of research into useful goods and services generally requires further development and engineering work. Public support for market-orientated development has been contentious, because it risks advancing the interests of some commercial entities at the expense of others. However, once technologies have proven their feasibility, a separate argument based on the need to deliver high-quality public services and other services of general economic interest again justifies public involvement. This support takes a variety of forms, ranging from venture capital participation to direct grants (examples include the eTEN, eContent and eContent+ programmes and the current Competitiveness and Innovation Programme). Recently, it has been argued that the development of common or interoperating technologies itself creates a public good by establishing a common European basis for the generation of open interoperability clusters. Support for development in these areas is provided by e.g. the European Technology Platforms. *Key challenges in this area are to ensure that*

[165] Generally in the form of requiring performance at least equivalent to a given standard or accepting certification as proof of compliance

[166] Use of public participation to enforce adherence to good practice (transparency, accountability, lay representation, etc.) may be a key action in this regard.

[167] It has been suggested that this may mean pushing for early and European-specific standards (based on the accepted interpretation of the GSM experience), but this may not be appropriate in all cases (e.g. HDTV, ISDN, LTE vs. WiMAX).

support flows to potentially valuable technologies that would not otherwise be developed, and that the support promotes development and exploitation in ways that increase effective and productive competition.

- Economic development – many overarching European objectives are tied to Treaty principles and common institutions such as the Single Market. In order for Europe to function effectively it must ensure that differences among member States and regions reflect comparative rather than absolute advantage. In other words, while there is no *a priori* justification for equality of outcome there is every justification for (rough) equality of opportunity; different parts of Europe will realise comparative advantages if and only if they start from comparable positions. This necessarily entails some remedial development activity in relation to public service infrastructures, institutions and public goods such as health and education. Because this 'levelling-up' is necessary to the attainment of other goals, substantial resource has been devoted to it and its decision-making has been insulated from other policy areas both by institutional separation and by devolution down to the regional level. *The key challenge here is to ensure appropriate articulation between other policies concerned with the Internet of X and the activities supported by the European Structural Fund and related instruments and institutions (e.g. ERDF, EIB).*

- Procurement – it is by now a commonplace that demand-pull is as important as supply-push in promoting innovation-led growth. This is particularly true in relation to the Internet of X; from its earliest beginnings in DARPANET to the large-scale public deployments leading the development and exploitation of e-identity technologies, the public sector has not only 'primed the pump' of Internet development but has strongly contributed to timely take-off and to a path of development that serves public as well as private interests. However, despite this oft-repeated observation and the enormous (40%) contribution of public procurement to overall GDP, the contribution of public procurement in innovation remains modest and patchy. *Key challenges are: Public contracting officers are institutionally risk-averse; cross-border procurement still represents only about 15% of overall public procurement; standard contract forms actively inhibit innovative solutions; legal restrictions inhibit (or discourage) exchange of ideas between purchasers and suppliers in advance of tender specification; post-award negotiation and partnership are difficult in law and practice; and political exposure actively punishes 'failed' projects (especially when new suppliers are involved) and imitation or adaptation of innovations developed elsewhere.* These challenges are beginning to be tackled through the use of specific provisions in the Procurement framework[168]. Other recent initiatives such as the Lead Markets Initiative and the (currently under development) concept of pre-competitive procurement of innovations in advance of formal procurement of goods and services that embody those innovations offer further promise, along with associated practices such as value engineering, strategic partnerships, multiple-sourcing and design competitions. These have not generally found specific

[168] Technical and competitive dialogues, contracts for variant solutions, functional rather than technology specific specifications

application in the Internet domain, but this can and should be explored in relation to the tech trends identified here.

- Public service delivery – in addition to purchasing goods and services, public bodies also act to deliver public services. The provision of public services on a pan-European basis lies squarely within the competence of the European Commission; it also essentially involves the use of convergent infrastructure, utility computing (in the broad sense used here), human-machine convergence (especially in relation to healthcare) and the Intelligent Web (in view of the different – and often higher – security, privacy, integrity and auditability requirements of public service delivery.
- Information policy – Beyond these direct instruments, European public bodies are engaged in continual information collection, interpretation and exchange. Sometimes, this is a direct part of or substitute for regulatory action or stimulus policy. In this connection, the provision of information relating to the Internet of X – its performance and the vision that informs public policy – is a powerful tool for managing the shared narrative or story of the Internet. This 'storytelling' function can close the gap between leadership and pre-commitment on one side and responsiveness and adaptability on the other. This is particularly relevant in view of the enormous quantity of information of varying relevance, coverage and quality; official information and official statistics stand out as common points of reference. Their use not only provides a reliable base for public, private and civil society decisions, but also lends a consistency to the decisions of different stakeholders that they might not otherwise have. Behind this public-facing instrument lie other activities – in particular monitoring (gathering information on relevant aspects of Internet structure, conduct and performance and producing reliable and relevant indicators) and recombination (e.g. data mashing to produce new indicators and new information products based – at least in part - on official information).
- Direct investment –The specific nature of the investments required for the Internet of X, and in particular the very large risks associated with the formation and roll-out of large, but technically specific infrastructures, may justify public investment. This is especially relevant where infrastructures associated with the tech trends discussed here are not neutral or can be made non-neutral by inclusion of features that limit interoperability, there may be a renewed justification for public investment. The point is not that this issue has not arisen already; where it has, it has been handled by regulation. *The challenge therefore is that some of the new developments may be less easy to correct once the infrastructures are in place – even net neutrality provisions are of limited utility when the network itself favours one technology over another*[169].
- Cross-linkage – perhaps the most effective policy lever is not a lever at all. It consists in recognising the connectivity implications of a whole range of existing policies. By making these policies 'connectivity-aware, ' by adopting policies that strengthen the positive connectivity advantages of e.g. Health, environmental, competition, etc. policies and by brokering coordination around a connectivity agenda between these

[169] An intangible example is the configuration of spectrum licences as paired (suitable for LTE) or unpaired (suitable for WiMAX).

policies, enormous improvements in connectivity outcomes can be attained without major change in policy, large commitment of resources or transfers of policy sovereignty and authority.

Of course, these instruments cannot be deployed arbitrarily. Beyond the general principles, it is worth recording that European interventions should respond to some degree of market failure (and avoid creating further market distortion) and that they should create European added value. The market failure part of this justification has been developed above, especially in relation to the (positive and negative) contributions of market forces to Internet development and the need to adapt economic regulatory models to the Internet of X context. The European added value derives from:

- Aggregation effects - economies of scale and/or scope (in research as well as deployment)
- Coordination and collaboration among multiple stakeholders
- Providing equality of opportunity and consistent framework conditions across Europe to promote cohesion and economic competitiveness
- Europe's global influence (visions, the 'European approach')
- Europe wide interoperability

Besides identifying the relevant instruments, a number of specific topics were identified in the expert workshop as being key for DG INFSO to pursue. These include:

1. continue its role as policy lead in areas that are to 'the ubiquitous Internet society' or 'Internet of X'; such as:
2. Ensuring privacy in a changing virtual environment.
3. Guarding openness and open networks; Ensuring the right level of Net neutrality; developing regulatory framework for quality of service offerings
4. Including the provision of sufficient bandwidth across Europe for the provision of seamless mobile Internet
5. Identifying the need for and designing effective 'public good' controls in the network
6. Supporting the further development Internet architecture
7. Promote the building Identity management systems for Europe ; and increasing the understanding of the importance and changing role of identity.
8. Actively investing in trust, and trust enhancing activity like trusted 3rd parties; effective cross border (legal) redress, enforcement.
9. Champion common standards and pre-competitive collaboration
10. Champion interoperability in all its forms, but in particular across borders
11. Develop technology as a complement to traditional policy tools

6.6 Application for policy development, and coordination

The second category of connectivity challenges still fit squarely in the range of DG INFSO's competences as they aim to deal with the *non-INFSO aspects required for enhancing positive connectivity*. These fit within some of the broader parts of the DG INFSO portfolio; both strategic policy formulation (e.g. post-i2010 policy) and the development of DGINFSOs roles and input in relation to segmented policy activities such as ICT-PSP and FP7. This includes the use of the Internet of X or Future Internet as a motif for policy coordination and information exchange within DGINFSO.

The third '*soft-connectivity'* category is also of a horizontal nature, but these fall outside INFSO's direct competence and would demand more of an advisory function of DG INFSO. This establishes the basis for making policies in a range of related areas more 'connectivity-aware' and thus ensuring both that the potential contributions of the Internet of X (which go well beyond those of the 'traditional' ICT view of the Internet by including the Internet of Things and the reconfiguration of various Internet aspects to deliver an increasing range of goods and other things as 'services.' In addition to the need to mediate the discussion with (and among) these 'external' DGs, the Internet of X framework highlights the need to revisit the consistency of the overall regulatory framework – in particular by considering interactions within the electronic communications services regulatory framework e.g. between the AVMS and e-commerce Directives, or in (separate) relation to the Universal Services and Open Network Directives. Beyond this, new interactions will come into the frame as the Internet of X expands – in particular in relation to Single market provisions relating to health, labour mobility and _perhaps most obviously) the Services Directive.

Some examples of policies that actively support DG INFSO's connectivity strategy and help address challenges:

a. Competition policy: avoiding abuse of market powers through technology lock-ins; and stimulating efficient competition among technologies

b. Better regulation policy: supporting 'self-correcting' market mechanisms and the active use of co-self regulation

c. Internal Market: support linkages across borders, interoperability and accompanying services

And in most other domains like the following examples

d. Trade: common standards; global rules of eCommerce; liberalisation of global telco markets and universal access

e. Enterprise: efficient and good connectivity supporting innovation and growth; high speed infrastructure and network access; seamless cross border services

f. Energy: Efficient management of the European Grid; network complexities by supporting network-based monitoring and management of energy use (e.g. via the Smart Grid and Smart metering); supporting more energy-efficient patterns of economic activity (eCommerce, remote working, transport-reducing collaboration platforms); and direct reduction in the energy needed to perform ICT-related tasks (e.g. the Utility Computing tech trend, thin clients, etc.)

g. Transport: Efficient road pricing and network/infrastructure management systems; flow control

h. Social policy: technology assisted living, telemedicine and eInclusion

i. Police cooperation and internal security: large scale databases and the broader issues around electronic exchange of information; eJustice

j. Etc.

The following Figure provides an exemplary snapshot of these cross-institutional impacts. The matrix in Appendix E is a useful tool to assess where the cross cutting connectivity issues are in each of the EC's policy areas.

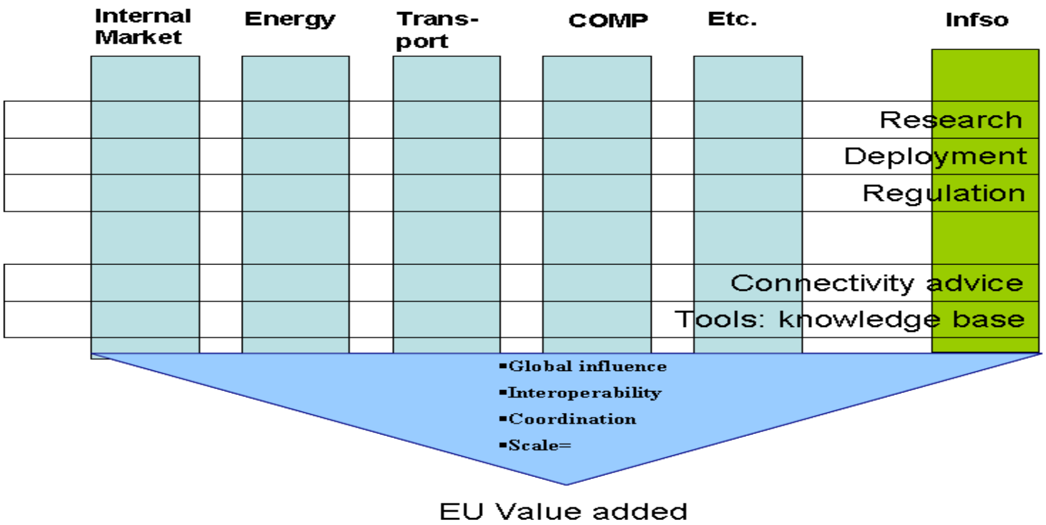

Figure 27: Cross-institutional impacts

6.7 Implications for Impact Assessment

Most substantive forms of European intervention (and the preponderance of Member State activities as well) are subject to Better Regulation, Impact Assessment and evaluation and monitoring requirements. This has two specific implications for connectivity policy in relation to the Internet of X.

First, it requires continuing information collection and indicator development to measure connectivity and its impacts. The analysis in this paper draws attention to the following elements of such a structure:

- It is necessary to distinguish the existence of a connection (e.g. a physical infrastructure), its usability (price, quality of service, reliability, etc.) and its actual use;
- Measures of connection or connectivity should take into account the opportunity cost of extension (e.g. whether an unconnected individual lives near a backbone) and the multiplicity of alternative means of connectivity (including physical

connectivity, to take account of the potentially greater reliance of people in remote areas on networks);

- The uses to which the network is put should differentiate (as far as possible) the broad category of economic or societal activity involved (e.g. communication, interactive engagement, commercial activity, search, content delivery, etc.) and its importance or salience to the parties involved (do there exist substitutes, do prices paid track cost and/or willingness to pay);
- Connectivity measures should also capture as much as possible of network structure – at a minimum this would include the number of connections each node has and their clustering, but could for some networks include centrality and direction. This can be used to determine whether networks generate asymmetries of 'connection power' and whether similar or dissimilar nodes are most likely to be connected;
- Current plans to monitor network traffic also hold out the possibility of a much deeper understanding of patterns of network use. These need not compromise privacy; even in anonymised form they can provide vital information on network structure and the dynamism of network use (traffic flows) and network structures (changes in link patterns, emergence of hubs and clusters, etc.). This can be particularly valuable in conjunction with information on innovation clusters and economic agglomeration, since only through this kind of information can causality be tested and the contribution of interconnectivity policy to broader socioeconomic interests be improved.

The second implication is that connectivity impacts should be included in the logical frameworks used for *ex ante* evaluation and impact analysis as well as *ex post* evaluation. Even where connectivity is not an explicit policy objective, it often forms an important part of the intervention logic, particularly as regards outcomes, sustainable impacts and contributions to macroeconomic and broad societal objectives. Indeed, for programmes that are small relative to the sectors they address or where impacts are likely to be indirect or delayed (e.g. the deployment and Framework Research programmes), such 'structuring' influences may be the most visible, lasting and valuable contribution. In addition, connectivity provides a 'common currency' for measuring cross-impacts of a wide range of policies that is relevant and proximate to each policy – in other words, it is not an unintended consequence, but one connected to the intervention logic and measureable by programme stakeholders.

6.8 Indicative set of supporting instruments

To implement this framework, certain resources must be in place. Some already exist, but could be developed further. Others are present only in fragmented or rudimentary form. The following is an indicative list.

- Knowledge base for INFSO future Internet and related projects
- Policy coordination mechanisms within DG INFSO and the rest of the Commission, possibly linked to a public bulletin board for EU ICT spending and activities (see US prototype: http://it.usaspending.gov/)

- Training of EC staff from other DGs in dealing with Networks and Connectivity
- Continued pilots for eIDM, and Interoperability
- Move research agenda to socio-economic impacts of the Internet of X
- Review of data protection directive and launching the concepts of data guardians and trusted third parties
- Strengthen mandate for the EC in international cooperation in Future Internet programmes; including through standardisation bodies and Internet Governance Forums
- Review the usefulness and role of trusted first parties

6.9 Final remarks

This report has discussed and linked together technologies, connectivity technology trends, socio-economic impacts, and policy challenges, ending with recommendations for possible policies and approaches. It launched the concept of the 'Internet of X' as a generic description of the multiple of concepts that express the trends of converging information infrastructures, increasing computing power and its embedding in everyday objects, the convergence of humans and machines and the growing intelligence of the web. The report should provide policymakers with a rich account of what the Internet of X may entail and what can be done to support its socially and economically beneficial development. A particular emphasis is given to the role of the European Commission and the EU Member States and impacts of Europe as a whole. This does not exclude the critical role other – non-governmental – actors may play, nor does it mean that the authors underestimate the role that other regions in the world have to play. The Internet of X remains a great unknown in many aspects of its structure and long term impact on global and local societies, as well as on individuals and companies, governments, and others. The authors express the hope that this report has made that uncertainty a bit more manageable.

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Annexes

Appendix A: Tech Trend Summary Tables

Annex table 1: Infrastructure convergence trend summary

The availability, functionality, interoperability, governance and diversity of a common (primarily *communications*) infrastructure (that part of the network available to all and providing a foundation for the others)	
Directly relevant technologies	▪ Increasing bandwidth ▪ Increasing processing power and performance ▪ Increasing electrical power and performance
Associated technologies	▪ More internet capacity (IPv6)
Key Uncertainties	▪ access to capital ▪ energy and environmental policy ▪ extent to which wireless technology will displace wireline technologies ▪ continued effectiveness of large powerful corporations and standard bodies in setting favourable standards ▪ ownership and effective control of infrastructure
Governance aspects	▪ ex-ante co-regulatory tools using stakeholders ▪ innovation support ▪ investment ▪ access regulation ▪ competition and consumer protection measures

Annex table 2: Human-computer convergence trend summary

The degree to which computation[170] will also be provided as an infrastructure – delivered as a utility in order to share fixed costs and minimise detrimental inequalities; structured as a 'universal' access to specific capabilities with at least minimal levels of functionality, affordability, and mobility. Because our primary focus here is on trends rather than design issues, it is also necessary to consider different ways that this notion of 'utility computing' might be provided in order to analyse the incentives that shape its characteristics and impacts, and to establish its relation to other clusters. This specifically involves the way processing power and data access are structured (e.g. grid vs. cloud computing).	
Directly relevant technologies	▪ Increased deployment of nanotechnology ▪ Cognitive computing ▪ Cybernetics, specifically cybernetic organisms. ▪ Immersive virtual environments
Associated technologies	▪ Decreasing size and increasing capability of embedded sensors ▪ Cheaper, faster and smaller RFID technology ▪ More tools for personal identification and authentication ▪ Immersive virtual reality environments
Key Uncertainties	▪ presence of a tipping point from limited, sector or application specific areas to widespread use ▪ social acceptance ▪ funding of nanoengineering ▪ presence or absence of trust ▪ the digital divide ▪ changing forms of criminal activity ▪ the mixing of real and virtual worlds and social harms that may result
Governance aspects	▪ Sub-optimal ex-ante regulation, coupled with more extensive ex-post 'work-arounds' and 'regulation after the fact' ▪ RTD support and deployment initiatives and procurement policy ▪ Stimulating technological solutions and innovations that are equivalent to compliance by applying a 'get-out clause' ▪ Policy issues defined at a global level ▪ Dealing with ethical dimensions, in the face of perceived assaults on what it means to be human ▪ Education ▪ Consumer protection policy ▪ Review of the meaning and reliability of informed consent and the implications of growing reliance on automated systems ▪ Reassessment of end-to-end principle ▪ Intellectual Property Rights (IPR) can be extended to biological forms and to hybrid processes. ▪ Governance and ownership of the information and data collected

[170] Note that a similar argument applies to e.g. content (access to public information, etc.) and transactional services (access to means of payment, etc.). These are not included because they are primarily socioeconomic trends, though they depend on the development of the technologies specific to the clusters.

Annex table 3: Utility computing trend summary

Just as functions can be shifted or integrated between different layers of the ICT system (e.g. hardware or software-based filtration systems), they can also be developed and exchanged across the human/system interface. These developments depend on *technologies linking specific system components and individual users* (e.g. remote and distributed sensors, new control and access devices, biometrics, etc.), *technologies that address the intangible or tangential* aspects of person/machine interaction (e.g. privacy-enhancing technologies, expert systems to support decision-making, avatars or software agents to extend human control or reduce the complexity of interactions) and technologies whereby humans (as individuals or organisations) enhance to capability of complex ICT systems (biocomputing, risk markets to elicit and aggregate human information, etc.)	
Directly relevant technologies	▪ Increasing digital storage capability and decreasing cost per byte ▪ Faster computation ▪ Evolving computer architectures ▪ Grid and Cloud computing ▪ Everything as a service
Associated technologies Key Uncertainties	▪ More internet capacity ▪ Open source software ▪ Feedback loops and network effects due to growth of network storage vs. increase demand of network computing ▪ Complexity of an Information Society based on utility ICT services ▪ Behaviour of individuals are themselves likely to change ▪ Proliferation of particular standards ▪ Extent and nature of social acceptance is the key uncertainty. ▪ Large data centres brings another set of uncertain dependencies: environmental security and international policy ▪ There can be no 'time-out errors' in era of utility computing
Governance aspects	▪ Competition policy ▪ Utility and service regulation ▪ Consumer protection regulation ▪ Privacy and data protection ▪ Regulation will become more principles- than rules-based ▪ Non-regulatory policies such as RTD investment and workforce and labour education to create the knowledge ▪ Policy objectives may move from protecting the rest of the economy from the bottleneck power of essential utility providers to protecting the provision (if not the providers) of these essential services

Annex table 4: The intelligent web trend summary

The term 'intelligent' is used in a wide variety of contexts relating to the Internet of X, including: technological developments that allow computer systems to 'automate' (perform) functions once the province of human agents; recognition of the semantic and syntactic links among knowledge objects at the most abstract layer of the network; the emergent properties of the Internet of X itself; and the fundamental architectural assumption behind the layered structure of the original Internet (the so-called end-to-end principle).	
Directly relevant technologies	▪ Convergence of applications ▪ More, easier and better creating & sharing tools ▪ Web 3.0 tools
Associated technologies	▪ Localisation of applications ▪ Decreasing size and increasing capability of sensors
Key Uncertainties	▪ Ability of regulation and other policies to engage the right stakeholders in the new participatory domain ▪ Policy response to the ease with which data from different sources can be mashed, assimilated and bolted together ▪ Societal reaction ▪ Consequences of facilitating the networking of a far greater range of people and organisations ▪ Undermine or confound the primacy of the nation-state ▪ Difficulty for content providers to extract economic value from their creations
Governance aspects	▪ Responsibility and accountability in this domain will fall between national regulators and industrial participants ▪ Policy likely to be primarily ex-post, though standard setting will still be important ▪ Highly flexible and determined by individual choice; opportunity for disruptive innovation ▪ Individuals, civil society and regulators at the 'ends' of the Internet are likely to be the main human and institutional loci of responsibility ▪ Regulators and policy-makers will have difficulty in adjusting ▪ Regulatory decisions will increasingly rely on the monitoring output of Web 3.0 tools

x

x

x

Appendix B: identifying and mapping the scenario dimensions

Establishing key scenario dimensions

Not all *combinations* of technologies and impacts are possible, even if the individual technologies and impacts are. This happens for two reasons.

1. First, the specific and measureable consequences we describe, model and assess are only the observable indications of 'soft' and unobservable common values, forces and 'laws' of nature and society. What we see is only part of what might have been; looking into the future means taking parsimonious and compelling account of what might be.
2. Second, these developments (in individual technology clusters, across socioeconomic domains, etc. are not independent, but interact; the early emergence of a particular technology may hasten or pre-empt the development of another, social responses to the deployment of a technology may distort the economic impacts, and so on. Therefore, it is essential to organise the wide range of possibilities into a small number of coherent clusters. But the clustering natural to, e.g. infrastructure technologies may have little to do with the clustering of services that run over them.

For deriving the scenarios we therefore identified a number of dimensions, which cluster the technological, governance and market factors that are common across trends, but have specific characteristics for each trend and play a decisive role in how technology is deployed and eventually generate socio-economic impacts and outcomes:

1. Ordering of combined tech trends according to technical 'dimensions':

   Open vs. closed

   Same vs. different

2. Ordering of combined socioeconomic developments according to 'dimensions':

   Governance: Government/Private sector

   Market: Competitive/Cooperative

Mapping technology dimensions

A first key uncertainty is the *openness* of future technologies and the Internet based on their exploitation. It has been observed that many of the deepest and most profound changes associated with the Internet can be traced to its generative character – the pervasive and designed-in openness that invites all kinds of stakeholders to participate and to contribute their energies and ideas as well as money and other tangible resources. In this it is important to consider:

1. Some forms of 'closure' such as certification, property rights and regulation have also played essential roles in rewarding creativity, mitigating damaging spillovers and reducing damaging (as opposed to exciting) uncertainty;
2. The economic and societal domains supported in part by the Internet have their own balance of openness and closure:
    - factor and consumer mobility underpin economic competition, but contracts must be enforceable to prevent fraud and erosion of trust in commercial settings;
    - societies likewise require a degree of openness for ethical and democratic reasons, but must be able to restrict access and impose laws where necessary.
3. There are strong forces seeking to increase openness and equally strong forces seeking to extend exclusion and control. This is not a struggle among equals, however:
    - benefits of openness tend to be collectively enjoyed, and may therefore be better at motivating collective action;
    - closure, on the other hand, builds individual advantage (e.g. monopoly profits) and thus powerfully drives individuals.

Both openness and its opposite therefore have demonstrated advantages and disadvantages and their own constituent beneficiaries and channels of extension; as a result, the future could be more or less open and this openness could have on balance helpful or damaging effects. For this reason, openness represents a key uncertainty as regards technological, societal and economic development.

Open: Open technologies or applications facilitate entry, exit and search by technology users and other Internet stakeholders. In deployment, they may lead to a single common approach or a differentiated, customised variability. Both (one-size-fits-all and diversity) are possible, even essential to an efficient outcome – for instance, we would not expect multiple protocols for signal transmission (thus standardising on TCP/IP) but we would not expect a single use or suite of applications[171]. An example of the 'common' outcome associated with an open regime is a common and freely available open standard or technology that serves as an infrastructure; people use it for different purposes, but it is 'customised' at a lower layer (e.g. TCP/IP is open and common, but used to enable http, VOIP, etc.). This openness makes it highly 'generative' – it allows (anyone can monkey around) and forces (by its 'plain vanilla character') bottom-up innovation – but mostly by and for the technical elites and those who have something to sell or provide to the masses. The physical metaphor is a highway. By contrast, a differentiated technology associated with openness might one that can be highly personalised or differentiated *by its users*, who are encouraged to interact at design level with the technology itself more than the way they

[171] For this reason, while distinctions between homogeneous and differentiated technologies and between the resulting homogeneous or differentiated Internet experiences are key aspects of the future of the Internet, we do not view them as alternatives (hence key uncertainties or dimensions) but rather as impacts or outcomes.

use it. This is related to the level at which innovation occurs – Spam can be managed by hardware, software or behaviour. Personalised software spam filters afford more (better) protection to the individual but (perhaps) less collective protection or deterrence (because spammers are likely to reach 'someone[172]'). The physical analogy is a commons or an airport runway without marked lane lines.

Closed: at the opposite end of the open/closed dimension lie technologies, business relations and regulatory systems that restrict interconnection, mobility and variability. The advantages of a closed-system approach include the internalisation of externalities relating to e.g. security, trust, reliability and other potential risks. The disadvantages include exclusion of specific groups, the weakening of voluntary contributions and the potential foreclosure of transactions between 'insiders' and 'outsiders.' Closed technologies can also be homogeneous or diverse. A proprietary technology may dominate the market (e.g. Windows). It is less generative (cf. the 'converging-but-closing' nature of Internet devices); innovation is far harder (it is hard to get access to change – or even figure out how to change things) and 'gatekeepers' assert rights over productive innovation to control it for their own interests. Limited consumer mobility means higher prices (and possibly costs) than under an open regime. The upside is provision of 'club goods' to those in (identical) walled gardens. The physical metaphor is a toll road. Greater (though not necessarily better) diversity is likely to arise from fragmentation and limited consumer mobility. Monopolistic competition means deadweight loss[173] (possibly without excess profit) but potentially close match of technology to user needs. However, it is not obvious that 'needs' *for technology* must be different just because user preferences for services differ, so variations may not match needs but instead amount to 'mere variety' without justification (or even 'IP lotteries' where differences reflect neither cost nor demand. The analogy is a 'small worlds' network.

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[172] See http://news.bbc.co.uk/1/hi/technology/7719281.stm (on spammers' business models) and http://news.bbc.co.uk/1/hi/technology/7725492.stm (on the value of non-technological solutions to organised criminal spamming).

[173] See http://news.bbc.co.uk/1/hi/technology/7695624.stm for discussion of responsibility in the cloud.

Annex table 5: Mapping technical dimensions

	Open	Closed
Same	Example – a common and freely available open standard or technology that serves as an infrastructure; people use it for different purposes, but it is 'customised' at a lower layer (e.g. TCP/IP is open and common, but used to enable http, VOIP, etc.). This openness makes it highly 'generative[174]' – it allows (anyone can monkey around) and forces (by its 'plain vanilla character') bottom-up innovation – but mostly by and for the technical elites and those who have something to sell or provide to the masses. The physical metaphor is a highway.	A proprietary technology may dominate the market (e.g. Windows). It is less generative (cf. the 'converging-but-closing' nature of Internet devices); innovation is far harder (it is hard to get access to change – or even figure out how to change things) and 'gatekeepers' assert rights over productive innovation to control it for their own interests. Limited consumer mobility means higher prices (and possibly costs) than under an open regime. The upside is provision of 'club goods' to those in (identical) walled gardens. The physical metaphor is a toll road.
Different	An open technology highly personalised or differentiated *by its users*, who are encouraged to interact at design level with the technology itself more than the way they use it. This is related to the level at which innovation occurs – Spam can be managed by hardware, software or behaviour. Personalised software spam filters afford more (better) protection to the individual but (perhaps) less collective protection or deterrence (because spammers are likely to reach 'someone[175]'). The physical analogy is a commons or an airport runway without marked lane lines.	A technology of fragmentation and limited consumer mobility. Monopolistic competition means deadweight loss[176] (possibly without excess profit) but potentially close match of technology to user needs. However, it is not obvious that 'needs' *for technology* must be different just because user preferences for services differ, so variations may not match needs but instead amount to 'mere variety' without justification (or even 'IP lotteries' where differences reflect neither cost nor demand. The analogy is a 'small worlds' network.

Note that these dimensions are strongly influenced by a range of policy forces and instruments (public and private) controlling access to and application of these technologies. Of particular interest are intellectual property rights. Without rehearsing the vast literature on the subject, it is worth noting the following key points:

Patents create exclusive property rights for specified technologies and uses. As such, they are inherently closed. To the extent that they are controlled by dominant players and offer strong network externalities, they also favour 'sameness' in the sense of a dominant technological paradigm with high barriers to exit (alternatives would not be able to interact well with the installed base). On the other hand, if patent inspectors ensure that

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[174] Zittrain (2008)

[175] See http://news.bbc.co.uk/1/hi/technology/7719281.stm (on spammers' business models) and http://news.bbc.co.uk/1/hi/technology/7725492.stm (on the value of non-technological solutions to organised criminal spamming).

[176] See http://news.bbc.co.uk/1/hi/technology/7695624.stm for discussion of responsibility in the cloud.

descriptions and protected uses are narrowly and precisely drafted, patents can encourage 'bypass' innovation. From the impact perspective, the key issue is the mix of

Diversity within the technology cluster paradigm (which makes the associated trend more robust and reliable);

Functional unity (avoiding inefficient variation); and

Diversity across technologies, which can lead to faster innovation and greater functionality, or to a welter of unnecessary or inappropriately-applied variations.

Standards can be considered collective property rights, defined in a more limited way but shared among many entities. They can be open or closed (esp. proprietary); some standards bodies have adopted procedures (like the W3C RFC process) that amount to a form of self-regulatory open democracy. They also compete for compliance or official standing. This competition, like the competition among patented technologies, can lead to similarity (winner takes all) or difference.

Innovative forms of property right (exemplified by the GPL or CC content protection licence forms) are specifically designed to preserve openness (both in the sense that they provide open access to the protected content or technology and (more importantly) in the inclusion of a 'hereditary' aspect that ensures open access top derivative innovations. They have been associated both with dominant-paradigm (e.g. Linux) and diverse technologies; the interactions are complex and need further analysis.

Mapping socio-economic dimensions

Competitive or cooperative attitude

A second key uncertainty concerns the balance between two opposed mechanisms or modes of societal engagement. These can be simply contrasted as *cooperation vs. competition*. Much has been written about these in relation to technology (e.g. standards vs. proprietary IPR), economic behaviour (e.g. collusion vs. market competition) and societal governance (e.g. joint action vs. democracy). As these examples make clear, each has (qualified) advantages and its own constituency. What is good (promoting the general interest) in one domain (e.g. cooperation in managing common societal problems or ensuring system reliability and interoperability or competition in matching demands to supply and ensuring fair prices) may be damaging in another (cooperation among collusive firms or 'race to the bottom' regulatory competition among governments). In the scenarios, this is interpreted as applying to the dominant domain: if the public sector dominates, then the competitive model is one of regulatory competition, with a possible danger of a race to the bottom - weaker regulation, favouring business interests over consumers (since businesses are more mobile) and restricted cooperation or harmonisation (thus resulting in greater international differences). Within and between countries, this is likely to result in greater inequality.

By contrast, the cooperative model of public governance should result in efficient and active international trade, equivalent standards and greater equality in terms of GDP growth, employment levels, social capital, etc. From the modelling point of view, this entails economic convergence in aggregate, supported by a combination of national and sectoral specialisation and joint policies. Where the private sector dominates, the largely positive (negative) view of cooperation (competition) partially reverses; competition among firms should result in faster growth, better products, more rapid innovation, etc. By contrast, cooperation amounts to collusion, with exclusionary standardisation, profits growing faster than consumer surplus, restricted rate (and certainly distribution) of innovation and IPR, and closed or proprietary consumer relation models, which in turn will strengthen inequality, especially along skill and income lines.

Public sector or private sector/citizen dominance

The third major uncertainty is whether development will be *dominated by public or private-sector interests*. Dominance by the public sector results in a reliance on rule- and law-based governance over markets, and heavy weighting given to such 'public good' interests as security, public service delivery, universality of services, etc. In relation to the economy, public dominance *ought* to mean a greater emphasis on competition (as opposed to market power) with consequently lower rates of profit. Growth should be slower but less volatile, levels of employment should be higher and wage growth should track profit growth. Also, the share of the public sector in both expenditure and (esp. RTD) investment should be larger. On the social side, progress should be more even – perhaps peak skill levels will rise less quickly, but will be more evenly distributed.

In terms of the global economy (and the coherence/effectiveness of the EU) there is something to debate in scenario analysis. Many would argue that public sector dominance should (via e.g. the plurilateral trade negotiation process) result in greater freedom of trade and more rapid convergence. But the failure of the Doha round suggests that protectionism is more likely under public dominance – this is certainly bad for efficiency (and thus for GDP growth and employment in aggregate) but may, paradoxically, result in a more even distribution, since the inherent advantages of the established economies and their rapidly-growing BRIC competitors mean that market opening often works to the disadvantage of less-developed economies. In particular, policy levers are key in establishing whether the kind of market opening pursued by governments will give small SMEs and producers of regionally-characteristic goods and services access to broader (European or worldwide) markets or will result either in their acquisition by MNEs (multinational enterprises) or their disappearance as MNEs penetrate their home markets.

By contrast, private dominance will lead to more rapid, volatile and uneven GDP and employment growth. Depending on other scenario variables, this may lead to further globalisation (emergence of a truly international business community capable of much greater efficiency and more rapid growth, but beyond the effective reach of any regulation).

Annex table 6: Mapping socio-economic dimensions

	Public/government	Private sector/citizen
Competitive	'Regulatory competition' or entrepreneurship; public bodies try to out-do each other in serving the public interest or attracting private-sector parties. Efficiency-enhancing if the 'right' things are mobile (capital, human capital, information, etc.) and if government competition helps align the interests of mobile and immobile assets. The outcome depends on democratic accountability (whether governance decisions are responsive to those affected or third parties). Could result in efficient outcome in which countries attract the technical deployments and economic entities most aligned with those of their citizens, or inefficient 'race to the bottom' or 'race to the top' scenarios of deficient or excessive control.	Ideal of the competitive market. Under some conditions (e.g. perfect information, small actors, no economies of scale and no externalities, etc.) it aligns technical, allocational, dynamic and informational efficiency; if the starting conditions (property rights, education, access and entitlements) are right and assets are sufficiently mobile, it even results in fairness. Can be inefficient if the ideal conditions fail, and may be excessively volatile. Produces only *aggregate* efficiency - winners from change could afford to compensate losers, but need not do so. Therefore, and especially if actors are myopic or risk-averse, it may prove divisive, with hierarchies rather than differences.
Cooperative/collusive	Multistakeholder governance; policies are coordinated (if not harmonised). Inevitable compromise and tension between alignment of interests and alignment of competencies. The 'goodwill' necessary for effective and sustainable arrangements may be at risk if democratic forces and divergent national interests inject competitive spirit. The 'full collusion' outcome may risk institutionalising composite organisations that are collectively more remote from their constituencies (through their mutual affiliation), and thus vulnerable to irrelevance, loss of engagement or collective deviation. Typically seen as good, it can result in a form of collusion against other public bodies or against the interests of e.g. citizen or business groups – or at least can be seen that way.	This is a model of inter-industry communication. In some cases (self-regulation) it can be more accountable and responsive, and better-able to produce realistic rules and high compliance than public governance (or even the competitive model); but it is also inherently collusive and likely to damage the interests of consumers, etc. (or at least to neglect them, thus producing situations where the aggregate gain to business is smaller than the aggregate loss to consumers).

Annex table 7: Relation between technical and socioeconomic dimensions

	Public\private	Competitive\cooperative
Open\closed	Tendency is to equate public with open, but there are some tech applications where the government is much tougher about restricting participation to authorised, entitled, etc. persons, or to citizens. Also, while some governments have climbed on the open-source bandwagon, it originated outside government, and at least partially in the private sector (Sun Java, Mozilla, etc.).	Competition requires a degree of openness or at least mobility, and cooperation requires or produces some form of binding. But this may erode: competing firms try to lock customers in; and cooperating governments (at least in Europe) regulate to increase the free flow of assets, people, information, etc. – at least among themselves (e.g. 4 Freedoms). The key lies in the characteristics of the driving technology cluster and the socioeconomic issues emerging from its use – some technology-born problems call for closer cooperation (e.g. global social ills) while others (e.g. market abuse) tend to reinforce parochial interests and competition.
Same\Different	The public sphere endorses (in principle) equal treatment within jurisdictions but differences between countries. Also, governments (at a given level) rarely compete to serve the same citizens, and tend to adopt one-size-fits-all solutions. Private governance can produce homogeneity as a result of convergence on the most efficient solution or standardisation on the demand or supply sides. Indeed, this interacts with the level at which differences are expressed – bespoke bundles can give way to vertical separation between infrastructure (one-system-serves-all) and commoditised (one-type-used-by-all) layers below highly personalised application, content, etc. layers. Scenarios are differentiated by whether technical economies of scale and interoperability in public services catalyse a common citizen experience, whether European harmonisation or competition (see right) produce the same options or the same choices and whether these differences occur between countries, ministries, market segments and/or citizen groups..	As mentioned, where citizens and consumers have similar needs, preferences or abilities needed to take advantage of the opportunities on offer, competition can produce similarity via either the emergence of a 'best' outcome or a 'race to the bottom' – the key difference being citizen or consumer voice (through accountability or consumer mobility). Competition can also produce differentiated outcomes, either when citizens or consumers differ or when the latter's ability to make comparisons or switch allegiance is limited. Where people differ and can move, competition should produce an 'efficient match' of demand and supply; where people cannot freely choose, differences may be haphazard or differentially serve the interests of (government or commercial) providers by reducing the degree to which they are in effective competition – in other words, monopolistic competition may is likely to be inefficient and may facilitate collusion. Cooperation can likewise produce similarity - especially when a common solution is chosen at a much higher (e.g. pan-European) level of aggregation, or difference – especially when economies of scale make it possible to offer a range of different solutions. By analogy with competition, the issue of whether this is beneficial depends on citizen/consumer input (here in the form of voice rather than mobility). It is worth noting that the formation of 'elites' (whether technocratic or political) works against efficient similarity or difference.

Appendix C: Framework for analysis of Economic Impacts

The economic impacts are assessed in the following framework. The technology trends and scenarios described in the foregoing chapters are analysed in light of known results from the economic literature in order to determine their likely effects on the key parameters of the IFS model and to identify the most relevant output indicators. This allows us to set up the model runs. The next step is to interpret the outputs by relating them to the trends and other scenario features. For structural reasons, the IFS model handles some aspects (esp. GDP and connectivity growth, productivity and inequality) more effectively than others (notably employment). Therefore, the model outputs are supplemented by more conceptual economic analysis as needed. It is also necessary to take into account some specific economic factors affecting future Internet evolution; these 'structural' elements also form part of the framework. The remainder of this section discusses these factors, lists the concrete steps followed and introduces the IFS model.

Overarching factors, defining the boundaries of the analysis

The economic impact analysis is not an attempt to predict all economic outcomes, but will be a broad analysis of the likely possible courses that the economy might take given the very complicated nature of rapidly changing technologies, highly interdependent economic relationships and overlapping structures and domains of economic life. Several inter-related developments need to be taken into consideration to fully understand the role of ICT.

1. The first is the influence of developing technology trends, especially the expansion of ICT infrastructures[177] that will play key roles in shaping future patterns of ICT investment and utilisation and hence productivity and growth. In rendering these trends in the analysis, we exploited the fact that the same market and political forces drive technology development and exploitation in all scenarios, albeit with different speed, extent and character. Additionally, many (most, even all) specific technologies

[177] In recognition of the technology trends, the term is used to refer to all technological aspects that serve as a common platform for economic activity, including: fixed-line, wireless and mobile *communications infrastructure*(s); the potential development of a complementary *computing infrastructure* (providing processing, storage, authentication, etc. services; and the *network operation and management infrastructure* (described as the 'Intelligent web' trend cluster).

contribute to more than one trend cluster.[178] The IFS model is an aggregate general equilibrium model and does not separate different ICT technologies. The approach taken is to associate individual parameters with individual trends in an iteratively consistent way and to perform sensitivity analysis of those variables.[179]

2. The second is the changing role and measurability of ICT-related inputs. A longstanding issue in measuring technology impacts is the appropriate treatment of numerical data. To form meaningful indicators, common units of measurement must be developed that aggregate different types of capital (e.g. communications equipment, computers, human capital, etc.) and that appropriately distinguish between 'flow' and 'stock' inputs. The usual approach (measuring capital formation by monetary investment data and measuring capital stocks by cumulating investment while adjusting for depreciation and replacement) is particularly inappropriate here for three reasons:
    i. ICT equipment prices have been declining[180] even as their functionality has been increasing – therefore, much of the productivity associated with ICT capital formation is not captured in investment figures;
    ii. ICT and ICT-related human/organisational capital do not depreciate according to conventional exponential formulae; ICT capital remains fully productive until it becomes obsolete ('cliff depreciation'), while the depreciation of e-skills and other intangible assets is *inversely* related to the intensity with which they are used; and
    iii. The technology trends themselves (especially Infrastructure Convergence, Human-computer Convergence and utility computing) entail shifts between categories – ICT services that used to be available only via investment are increasingly provided as services or even for free as part of common infrastructures.

3. A third factor is the importance of relative as well as absolute technological progress. Studies of ICT investment not only fail to validate classical assumptions of diminishing returns to scale, but also indicate the growing importance of 'competitive

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[178] The different contributions of technology trends and other elements to the scenarios are indicated in 0; this gives rise to different parameters and assumptions. This is the only sense in which the 'impacts of individual trends' are assessed. Specific technologies cannot be predicted, but the development of the trend clusters described in functional terms is robust and thus the appropriate basis for analysis.

[179] In principle, measures of GDP, employment etc. could be regressed on empirical data on historical development of specific trends. But micro studies indicate clearly that the results are likely to depend critically on unmeasured differences in the distribution of ICTs across firms and the correlation between technology deployments across rival or complimentary firms. For this reason, aggregate impacts are measured here (as elsewhere, see e.g. van Ark et. al.(2005) via growth accounting.

[180] Whether this will continue depends on the dynamics of ICT diffusion; any new generation and most transitions from one sector of application to another generate high initial prices followed by a 'shake-out' drop in price and (as the technology beds in) increases in net productivity. The work of Aghion and Howitt (among others) has demonstrated that this pattern of cyclical or sporadic productivity growth is characteristic of ICT-driven growth and goes a long way to explaining the 'Solow paradox'. It is, however, difficult to predict when, where and how strong these interruptions may be.

modernisation' (where firms – especially SMEs – collectively overinvest in ICTs in order to remain competitive with each other). This possibility of 'overshoot' in turn strengthens the business case for collective or utility provision of key ICT resources. The picture is further complicated by complementarities among different types of asset – e.g. that the productivity of communications facilities is enhanced by investments in computing resources and that the rapid pace of technological change both increases the need for e-skills and increases the rate at which they become obsolete.

4. A final factor is the presence – especially in recent data – of a succession of financial sector shocks, including the .com bubble and its bursting and the recent economic upheaval. What is not clear is the extent to which these represent transitory shocks, underlying trends or sources of path-dependent cumulative change. All the scenarios are particularly vulnerable to such increases in volatility, particularly because each one involves large multinational enterprises in key roles. Such firms are very exposed; this in turn affects government policy. The recent crisis shows this clearly: governments are tending to adopt more stringent and proactive globally-coordinated regulatory policies while at the same time (it currently appears) putting up (economic at least) trade barriers.

Unmodelled influences

A further adaptation of the model to this study is based on the following inferences about unmodelled (in IFS) specific policies:

1. Product and labour market regulation affect the form and speed of ICT implementation;
2. The combination of (regulatory, procurement, standardisation, economic/RTD stimulus and trade) policy and the competitive climate drive the extent, pattern and speed of firms' ICT adoption decisions;
3. The impact of policy and competitive climate at the sector level depends as well on selection – e.g. if regulatory burdens fall disproportionately on e.g. SMEs or firms from specific countries, their participation and contribution to growth are likely to reduce;
4. These selection effects in turn may reduce productivity in the ICT sector[181] by reducing effective competition, discouraging complementary investments and altering the pattern of off shoring and/or outsourcing;
5. The combined impact of both policies and technologies on employment is not captured in the model, so it is necessary to consider employment as an explicit part of the ex ante assessment of specific policies rather than as an output of the model – the model measures the formation and quality of human capital and the demand for units of labour input, so it does (in the Social Accounting Matrix) measure flows of labour from and income to high-skilled and low-skilled households as a group. But it cannot capture the degree to which, say, a fall in income takes the

[181] Bartelsman, Perotti, and Scarpetta (2008)

form of lower wages or reduced employment, due to the complexities of labour market interactions and the very large and highly policy-driven differences among countries. Instead, we use economic analysis to point to likely impacts, for instance by considering the rate at which skills become obsolete, the pattern of educational expenditure and the overall impact on e.g. job security in the scenarios.

Steps in the analysis

The steps involved in assessing economic impacts are as follows:

1. Identifying key model/policy parameters affected by the technology trends and scenarios and the most relevant output indicators;

Describing the channels through which technology trends affect key economic impact variables;

Discussing the contribution of each technology trend to the three scenarios in terms of the underlying dimensions defining the scenario;

Rendering the scenarios in terms of IFS model parameters;

The IFS production function uses input indicators to drive productivity parameters. In this study, for instance, policies relating to education and health expenditure affect human capital quality, while networking and technology indicators affect multi-factor productivity. Impacts on GDP growth, productivity, inequality, etc. are measured by simulating the world (socio) economic system from the present to 2020.

Within each scenario we will also focus on regional comparisons among EU15, EU27, North America, Japan and Korea and the BRICs.[182]

Running the model for the base case and the three scenarios;

Conducting sensitivity analysis on the parameters and assumptions;

Producing the output measures/indicators for subsequent analysis[183];

Assessing the pattern of impacts for *each* scenario;

Comparing results across scenarios;

Reviewing outcomes against general economic theory and specific research done by our sister project, "The Economic Impact of ICT" SMART N. 2007/0020[184]

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[182] Turkey and other accession countries were not included as the timing and conditions of entry we cannot predict despite the big influence they would have on the analysis

[183] This Chapter reports a subset of these data; a full database is available.

[184] The results seem to be in broad agreement, but full validation has not been completed for this draft (full results are not yet available and further discussion is needed to reconcile the different levels of aggregation, modelling strategies and specificities of the two studies.

Developing an overview of the results: likely emergent policy issues; implications for the impacts of (esp. economic) policy; and relation to exogenous developments.

Introduction to IFS as used in this study

The present study assesses the impacts of technology trends on economic performance using a common macroeconomic approach to modelling ICT transmission mechanisms; Computable General Equilibrium (CGE) modelling. A CGE model is a multi-equation growth model that uses historical economic data to estimate how an economy might react to changes in policy, technology or other external factors. The comparison by Guerrieri *et al* (2007)[185] of seven modelling approaches to ICT impacts[186] concluded that the best model in terms of handling the ICT sector (treating it endogenously), its impact on the economy (via ICT spill over and diffusion effects) and its comparative cross-country effects was the open-source International Futures System (IFS) model developed over three decades and numerous applications by Professor Barry Hughes of the Graduate School of International Studies, University of Denver. The European Commission (DG INFSO) has long supported the development and use of IFS; firstly through the TERRA 2000 project on the sustainability of the Information Society[187] and currently through the "Forecasting ICT" project. The version of the model used here represents electronic networking via the number of networked persons and internet use density, connected by explicit transmission channels, which form a critical feature of any 'ubiquitous internet society'. The model allows an analysis of broad classes of economic impact across scenarios, countries (regional groups) and over time.

IFS suits the purposes of this study[188] because its wide range of input parameter values provide a sensitive interface to the complex interdependencies of the macro-economy. Its accessibility and flexibility are of continuing value in preparing this study and for extension to investigate other scenarios, incorporate of new data and assess specific policy proposals; the publicly available source code facilitates modification to explore alternative mathematical relationships between uncertainties, levers and measures. In particular, because IFS is a general equilibrium model, it offers a valuable point of comparison to the

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[185] Guerrieri and Padoan (2007).

[186] They evaluate the capabilities of the IFS relative to 7 other global CGE (computable general equilibrium) models, NEMESIS, ERASME, MULTIMOD, WORLDSCAN, QUEST, NiGEM, Oxford World Macroeconomic Model and the BAK Oxford New IIS (NIIS) Model; GEM E-3 Model. They chose the IFS model since it includes a specific ICT sector and it allows ICT to exert its impact on the economy via different channels, rather than being modelled as a simple input in a standard production function

[187] In which the model was adapted in conjunction with one of the authors of the present study to incorporate an endogenous ICT sector.

[188] Although adding detail can give the impression of greater completeness and more insightful examination of detailed policy levers, it may not usefully reduce uncertainty: no additional level of detail can ever produce reliable predictions of an unpredictable future; errors in the data may outweigh additional resolution; comparisons become harder; and highly nonlinear innovation competition and other policy mechanisms are not 'smoothed by aggregation.' The approach taken here is to use the model to give the overall shape of impacts, reserving detailed discussion for workshop scenario analysis.

more common partial equilibrium models used in much of the literature – perhaps the most essential characteristic of the Internet Society is its complexity – the importance of systemic interactions in shaping future evolution. General equilibrium models are precisely intended to capture such interactions – perhaps not the full complexity of the real world, but certainly much more than partial equilibrium neoclassical models, whose more precise econometric estimates form a valuable complement[189].

In this study, this analysis takes the form of using the IFS model as a way to explore different possibilities left unresolved by the literature, in particular those areas where two-way causal links form an essential part of the structure. This is fundamental to economic analysis; as Alfred Marshall noted in 1890 *"You can no more tell which determines price, supply or demand, than you can tell which blade of the scissors does the cutting. It is the interaction of the two that does the work."* This insight has been progressively applied – for example with the emergence of endogenous growth theory, which made explicit use of the way economic and technological developments determine each other. Therefore, in order to assess the likely economic outcomes under different scenarios it is necessary to qualify empirical regularities and to explore various mechanisms within the overall causal structure.

Factors in ICT adoption

ICT adoption is driven by a range of factors that include the following.

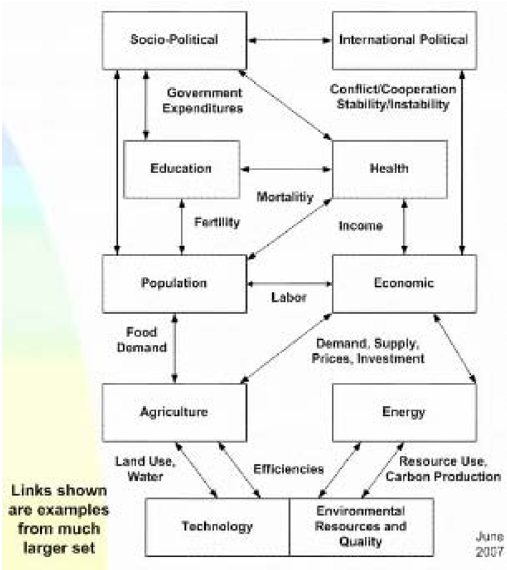
1. Firm behaviour and organisation effects: at the meso (industry) level, adoption is related to supply of skills, wages, competition, regulation and local infrastructure. In turn, adoption changes the flow of information, internal organisation and market coordination. Because consumer access to ICT can also enhance consumer sovereignty, even more ICT is required within firms to deliver consistently high levels of customer service. Moreover, ICT affects authority relationships and decentralisation of decision authority.
2. Human capital and skill diffusion: ICT and human capital are complements and their diffusion patterns and their levels of development are strongly interrelated.
3. Labour regulation: European labour regulation has tended to encourage capital deepening by raising labour costs. Because ICT is part of capital, this should imply a greater rate of diffusion in Europe compared to the US. However, the skill requirements associated with ICT adoption produce a contrary effect – realising high returns on ICT investment often requires significant organisational adjustment, reductions in the number of unskilled workers and even turnover among skilled workers (as skills become obsolete). If labour regulations (e.g. high firing costs) make such adjustment difficult, firms will be reluctant to increase ICT in the first place – or at least to make optimum use of ICT investments.

[189] The current EC-sponsored development of IFS is deepening the treatment of ICT in order to: 1) shed greater light on the long-term drivers of ICT adoption and diffusion; 2) improve ICT adoption and diffusion forecasts; 3) further endogenise ICT as a sector of production within the IFS economic model; and 4) better integrate energy consumption and ICT.

4. Product/market regulation: The literature on broadband diffusion has demonstrated that inter-platform competition (e.g. between DSL and cable) increases broadband penetration rates. By contrast, intra-platform competition (between different users of the same infrastructure) has small but significant "splintering effects" – consumers have lower adoption incentives when faced with multiple similar options with network effects.

The IFS model

The IFS model[190] is global simulation system with an extensive database for 164 countries over as much of the period of 1960 as possible. The methodological approach is best described as a 'structure-based and agent-class driven modelling'; the model iterates over time by partially adjusting variables linked by structural equations in the direction of equilibrium. The overall structure of the system is shown in Annex Figure 1.



Annex figure 1: overview of the IFS system

The scenarios were 'rendered' in the model by identifying variables most likely to be affected, tracing their exogenous drivers ("policy variables" in the language of IFS) and adjusting those to fit the scenarios.

The framework developed for this purpose[191], is shown in Annex Table 8. The drivers in the first column produce changes in ICT, which affect economic outcomes both directly and via induced changes in innovation and the production of knowledge.

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190 Hughes and Johnston (2005). Details can be found at: http://www.ifs.du.edu/index.aspx

191 Concomitant with framework being developed for forecasting of ICT in IFS l by the University of Denver.

Annex table 8: IFS framework as applied in the impact assessment for this study

Policy variables acting as ICT drivers	*Innovation, knowledge impacts*	*Economic impact*
Expenditure on: • R&D (innovation) • Health (biggest innovation user) • Education (main innovation facilitator) Investment in ICT sector Foreign Direct Investment Trade liberalisation Political freedom	Creation and diffusion of: • knowledge capital • social capital • human capital	Output: growth and productivity Productivity gains in ICT, manufacturing and services (including impact of globalisation) Employment Welfare
Framework influences		
Attractiveness to venture capital from home and abroad IPR mechanisms, public and civil involvement, financial viability, Standardisation	Cooperation and networking Ability to exchange information	Public, private and civil sector attitudes to innovation and new technology Capacity to develop innovative solutions (at all levels), absorb innovation

The specific variables are listed in Table 9 below are rendered to express particular areas of interest for our study: Internet Connectivity, Governance, Responsiveness to government policy, Government public goods expenditure, Redistributive policy and other inputs (i.e. business FDI). Projections were made for a base case and each of the scenarios. The output indicators were captured over time and by country and are also listed at the bottom of this Annex, following the categorisation: growth, productivity, distribution. Labour is not projected directly, despite the conceptual analysis of employment-related impacts. Neither IFS nor the sister project focusing on ICT economic impacts directly include the labour market. The indicators that were applied contain various expressions of GDP, and MFP, role of government, indicators for participation, gender and equality (Gini curves) and human capital development, connectivity and networking.

Annex table 9: Output variables captured for this analysis

Variable	Notes
Foreign Direct investment as a % of GDP	Private FDI flows between countries
Investment by sector as a % of GDP	Sectors: agriculture, energy, manufacturing, materials, services, ICT
Gross domestic product	
Gross domestic product per capita	
Gross domestic product growth rate	
Per-capita value-added in services with ICT	
Multifactor productivity growth rate (MFP)	The 'technology factor' in the production function (explains residual GDP after contributions of labour and capital): the sum of a global productivity growth rate driven by the economically leading region, a technological premium form GDP per capita and a scenario-specific factor
Human capital contribution to MFP	Based on educational expenditure, years of education, health expenditure and life expectancy
Knowledge capital contribution to MFP	Based on R&D expenditures and economic integration
Physical capital contribution to MFP	Based on transport, electricity, telephones, Internet use
Social capital contribution to MFP	Based on socio-political freedom, government effectiveness, corruption, economic freedom
Government consumption	Total level of government consumption

World Bank government effectiveness index	
Government expenditure	
Hard or capabilities power	
Technology power (at PPP)	
Global Gini coefficient	Measure of between-country income inequality
Domestic Gini coefficient	Measure of within-country income inequality
Globalisation index	
Network infrastructure	Internet use density
Telephone infrastructure	Telephone network density
Connectivity	% of population connected to electronic networks
Knowledge society index	Based on World Bank index
Female share of labour force	
Literacy rate	
Materialist-postmaterialist index	Projection based on World Values Survey index
Traditional-secular rational index	Projection based on World Values Survey index
Survival-self expression index	Projection based on World Values Survey index
Women's literacy rate	
Gender empowerment measure	Based on United Nations Human Development Report
INTR	Real interest rates based on overall balance between production and consumption

Although employment is an increasingly important economic impact and despite the conceptual analysis of employment-related impacts we do not project it directly. Neither IFS nor the sister project focusing on ICT economic impacts directly include the labour market.

For ease of comparison, the detailed data on 194 separate countries were aggregated into regional groupings. To put these in perspective, it is useful to classify them according to the World Economic Forum (WEF) development schema, as shown in the Annex Table 10.

Annex table 10: Regional aggregates

Region	WRF classification[192]
EU27[a]	innovation-driven (on average: Hungary, Poland, Czech Republic are making the transition to innovation-driven status)
EU15	innovation-driven
North America (USA and Canada)	innovation-driven
Japan and Korea (South)	innovation-driven (Korea is classed as transitional)
BRICs (Brazil, Russia, India, China)	resource and efficiency-driven

Rendering the scenarios: Economic impact mechanisms associated with the technology trends

The main ICT developments have been aggregated into four clusters of tech trends. These tech trends interact with the economy in similar but distinct ways. The Table 11 below maps the trends against a set of economic indicators, both those in the IFS model and others of particular relevance, such as web 2.0 innovation, and lock-in. It is important to clarify that this is not a direct translation. The IFS model includes high-level policy settings

[192] Connectivity Scorecard 2009

for e.g. government effectiveness, public sector support, etc. and also allows scenario-specific modifications of both the development of key parameters (e.g. MFP) and of the influence of policy variables and scenario-specific system parameters on each other. Thus, for example, in modelling the Infrastructure Convergence technology trend, we need to consider how it will affect each component of MFP growth, and how additional impacts will change the translation of productivity (potential GDP in the model) into actual GDP.

These additional impacts arise from the operation of e.g. regulation, induced changes in the level and applicability of skills, the level and nature of market competition in the different sectors of the model, the level and nature of firm costs, and so on. Rather than giving a detailed account of how each model parameter was modified, we find it more appropriate to map the technology trends against key indicators in tabular form. In addition to exposing the logic behind the rendering of the trends (which would otherwise be obscured by model detail), this presents elements of the underlying conceptual economic analysis that are useful in drawing out unmodelled impacts.

Annex table 11: Framework for technology trend impacts

INDICATORS	Infrastructure	Human-computer	Utility computing	Intelligent Web
REGULATION, GROWTH AND PRODUCTIVITY				
Economic regulation	Creates basis for transition from command-and-control infrastructure regulation to liberal regime based on competition among compatible infrastructures.	More pressure for societal and safety/technical regulation; little antitrust implication.	Addition of utility regulation of computation (especially under the grid model) with additional rules governing liability for incorrect computations and data storage integrity/privacy.	Possible replacement of current regulation by technical complements or alternatives
GDP growth	Accelerates GDP growth (in line with standard literature on e.g. broadband impact on GDP)	No impact beyond acceleration of productivity	Accelerates GDP growth (in line with standard literature on e.g. broadband impact on GDP)	Accelerates GDP growth (in line with standard literature on e.g. broadband impact on GDP)
Labour productivity, TFP/MFP[193]	Second-order improvement: better skill match; home-working; lower cost of infrastructure services (capital requirement); partial substitution away from labour; rising labour productivity.	First-order improvement for data-intensive jobs (improved input/output interface)	First-order improvement: better match of labour, computation; second order: lower capital cost. Utility implies common interface, less cost of proprietary systems, disruptive specification changes and wide user base for innovation.	Second-order effect through improved skill/job match

[193] Can't easily differentiate; technologies can be implemented in labour-, capital- or other-saving ways

INDICATORS	Infrastructure	Human-computer	Utility computing	Intelligent Web
ICT MARKET FACTORS				
Competition	Improved by: reducing capture from infrastructure layer; direct rather than facilities-based competition. Possible foreclosure by dominant common infrastructure providers. Depends on critical uncertainty as to how infrastructure provided, priced.	Proliferation of personalised applications, customer differentiation *can* (dep. on scenario) raise welfare (if competition matches consumer needs) or cut welfare if monopolistic competition arises from lock-in or creation of artificial diversity (in BW especially)	Utility regulation varies between competitive, monopoly outcomes depending on public-sector control. Open, self-regulated *cloud* with common interface standards. has competition among small utility computing providers. If cloud has poor regulation, high lock-in or low trust, demand may be too thin. *Grid*: probably oligopoly; better than monopoly but worse than competition unless weak regulation lets grid providers use interconnection to sustain collusion.	May: improve ICT service competition by better end-to-end access; sustain traffic prioritisation. Lower competition through creation of 'quality-streamed' market segments, but welfare may rise if consumer search is easy or lower congestion outweighs deadweight loss. Distributed 'intelligence' model may give effective competition among Web components.
Vertical integration	Converged (interoperable) infrastructure should limit vertical integration based on segmentation, or at least 'shrink' it to the service, application, content layers.	Little impact, except in HW, SW, content and (possibly) connectivity bundle segmentation.	With utility regulation and limited foreclosure, vertical integration weakens. But horizontal integration (bundling computing with other services) more likely.	Little clear impact – possibly less vertical integration based on providing dedicated web facility (fibre ring, VPN), making internalisation less necessary.
Lock-in	Very low – common platform allows multiple interconnecting systems on the infrastructure.	Possibly very high, especially due to dependence on specific interfaces, collective lock-in through shared use.	Probably relatively little.	No clear impact. Secondary *drop in lock-in at individual system level* by shifting functions responsible for lock-in to common network. *Stronger switching-cost lock-in at network level* because change needs coordination.
Product/service diversity	Much greater: cuts vertical restraint from infrastructure; raises ability to interconnect with other infrastructure components (e.g. mobile, fixed-wireless, fixed) for similar functions.	Very high, due to scope for personalisation.	Likely to fall initially; computing will become commoditised and so will services using it. Over time, the ability to provide adequate work for differentiated systems may increase diversity (e.g. graphics engines)	No clear impact.
Economies of scale	Realised (stronger)	No impact	Realised (stronger)	Unclear impact; may ease aggregation (e.g. if better connectivity justifies larger server farms).

INDICATORS	Infrastructure	Human-computer	Utility computing	Intelligent Web
Economies of scope	No clear impact	Very large scope economies to fit users' differences and demand growth.	Larger volume, range of computational tasks handled in cloud or grid justifies investment in increased flexibility.	Increased by e.g. traffic management systems to balance a greater range of traffic types (e.g. prioritisation, latency-tolerant vs. near-real-time traffic)
International Trade	Stimulus	Secondary trade stimulus, but possibly reduction in some areas.	Little effect, except if it reduces international differences in ability to produce computer-based products.	Better ICT support for trade and cross-border eCommerce; big bottlenecks: different legal regimes; trust in aftermarket, etc.
DISTRIBUTION OF GAINS				
Within-country inequality	Improved connectivity supports universal service, hence reduces inequality	Gap between enhanced and unenhanced exacerbates existing inequality	No obvious impact on income inequality, but may reduce welfare inequality (esp. under cloud model)	May worsen tipping if "intelligence" dominated by monopolies; skill-based inequality cut by NW alternatives.
Between-country inequality	Increased gap between leaders and laggards (infrastructure inequality driven investment rather than technology; laggards unlikely to integrate e.g. fixed and mobile.	Secondary correlation with income, cultural acceptance of "enhancement", gaps exacerbated if laggards don't regulate, suffer value-driven rejection, take up inappropriately.	Global availability should reduce between-country inequality through outsourcing.	Some reduction in leader advantage due to improved management of global information flows.
LABOUR ISSUES				
Employment	Increase: productivity enhancement.	Increase: productivity enhancement; labour-intensive new products; specialisation.	Possible decline: substitution; migration of computation-intensive tasks out of 'paid' economy (esp. in cloud)	Better labour market matching should cut frictional unemployment (natural rate shift?).
Labour mobility: geographic (better labour market, efficient wages); occupational (lifetime earnings rise, exploiting new niches)	Facilitates home working, may cut movement to new places, occupations, improved delivery of LLL, hence re-skilling.	Increase mobility by cutting access barriers, esp. for disabled, new occupations, displaces automated services.	Better access to computing gives people access to more types of job, may cut rents to (employment in) proprietary computing, storage service provision.	Better prioritisation, security, facilitates home working.
Returns to education and training	Widely available education may cut short-run returns (more educated job competition), but raise long run return (higher skills needed to meet needs of those educated by, working via common infrastructure.	No major impact; possible enhancement of education via new interfaces, but this is uncertain.	Increases utility of basic computing skills, which may encourage uptake and exploitation. Again, possible short-run (quantity effect) decrease in returns, then secondary (quality) increase.	Little major impact.

INDICATORS	Infrastructure	Human-computer	Utility computing	Intelligent Web
Skilled wages	Probably rise, due to greater global skill access	Probably rise due to high skill needs of production and service (initially)	Likely to drop, due to computer/human substitution	No clear impact.
ICT AND INNOVATION				
Returns to innovation	Greater returns to infrastructure-using innovation, lower returns to infrastructure innovation (more competition, already have efficient combination of hybrid capabilities)	Explosion of new and highly-differentiated products. Some scaling down if aimed at niche markets, but need common modular innovation platforms.	Lower CAD costs, may increase innovation but reduce financial return (competition). Secondary innovation wave of products exploiting the ubiquity, performance enhancement, mobility and robustness of utility computing (e.g. 'smarter' location-based services.	May allow better protection and exploitation of IPR, hence higher expected returns.
Web 2.0 Innovation	Little impact	Stimulates development (esp. of content)	Big stimulus, as above	Aids P2P innovation unless 'Intelligence' used to inhibit P2P (traffic shaping, DPI). (Reflects public/private aspect of scenario.
Paid innovation	Post convergence, little infrastructure innovation, but secondary stimulus to enabling services and applications over any interoperating infrastructure parts.	Very big stimulus to develop new interfaces, applications.	Stimulus to (esp. SME/personal) CAD-based innovations (lower entry barrier), stimulus to unpaid, bottom-up, etc. innovation.	Facilitates joint innovation (co-working, improved performance, security) and thus innovation-based joint ventures.

Implementing the scenarios

Role of technology trends in the scenarios

The technology trends contribute in different ways to the scenarios described. Annex table 12 indicates the main features of this contribution in terms of the impact mechanisms associated with the trends.

Annex table 12: Contribution of tech trends to scenarios

Trend\scenario	Open world	Connecting world	Scattered world
Infrastructure Convergence	Transparent, cheap, global communications, variable QoS; reduces vertical monopoly power.	Patchwork of interconnecting infrastructures, tiered QoS, variability in Universal service/access costs and provision. Potential global extension of facilities-based competition.	Variable convergence levels, poor interoperability (by mode and region), costs rise, technology development distorted by 'extensive' competition. Reinforcement of regional monopoly. Potential emergence of new market domains not aligned with national boundaries.
Human-computer	Inequality based on enhancements (esp., in	Access to both dangerous, productive	Wide differences in availability, safety, acceptance

Trend\scenario	Open world	Connecting world	Scattered world
Convergence	labour productivity), new global 'experience' industries, deeper interactive virtual environments – possibility of addiction (new source of monopoly power)	enhancements coordinated by public sector.	between technological 'compatibility clusters.'
Utility computing	Open cloud model of computation, storage provided as public goods under Linux/OS-like model.	Location-based public utility regulation (extension of telecom regulation), possible excess capacity[194], extended Universal Service provision. Private 'grid' provision.	'Forked cloud' (closed proprietary) provision, limited mobility of data, computations; increased lock-in of computation-intensive users.
Intelligent Web	Control moves to centre of network and concentrates power in extended versions of current industry-civil society governance groups. Increased global market access for conforming entrants.	Restoration of end-to-end principle, with possibly greater participation of national governments in Internet governance	Concentration of influence at cyber-borders that reflect existing jurisdictional, sectoral and market boundaries. Creation of favoured network havens.

Dimensions and socioeconomic aspects

As noted in Chapter 3, the scenarios are described along three principal dimensions (open-closed, public-private, cooperative-competitive) with a fourth dimension (same-different = extent of variety) emerging as a result of the scenario evolution. This has specific implications for both the conceptual analysis of economic outcomes and the adjustment of IFS parameters as indicated in Annex table 13.

Annex table 13: Economic characteristics of the scenarios

Aspect	Open world	Connecting world	Scattered world
Openness	Open	Open	Closed
Governance	Private	Public	Private
Mode	Competitive	Cooperative	Competitive
Variety	Strong lock-in, tipping; some monopolistic competition	Modest 'paid' variety, high customisability	Excessive variety used for lock-in, market segmentation. Limited scale prevents many new developments.
Innovation	Cost-reducing innovation, rapid introduction, rapid obsolescence	Bottom-up innovation possible, also innovation targeted on public needs – may be slow	Excessive patent thickets, clusters and pools; mostly top-down invention, 'closed

194 Following standard Averch-Johnson effect if computing utility regulation based on rate of return)

			devices' and limited scope for informal collaboration
Infrastructure	Little long-term investment, except in leading countries	Much 'connecting' infrastructure provides through public means.	Few countries can justify extensive roll-outs
Competitive mode	Concentrated infrastructure provision, 'branded' empires dominated by big MNEs.	Interoperability, low entry barriers produce effective competition in most layers	Cutthroat monopolistic competition, possibility of global collusion
Vertical integration	Low	High vertical integration, regulated for open access	High, facilities-based, walled garden
Public subsidy	Low	High	Variable and aligned with industry interests.
Inequality	Strong social divides by income, education, social advantage.	Inequality reduced among nations, but still high in some (between skill levels)	Elites do very well, but rising inequality within and among nations.
Labour			Local excess labour supply, low wages and job uncertainty, high unemployment and long spell durations
Regulation	Adequate locally, poor global coordination	Strong, effective guard against foreclosure	Weak, captured by dominant tech owners, race to the bottom
Global problems (e.g. financial stability)	Little progress due to lack of regulatory control or purchase	Possibility for new forms of partnership, regulatory coordination	Little progress due to lack of overriding identifiable common interest

Parameter settings used

The main parameter settings used in rendering the scenarios are given in the following Table 14.

Annex table 14: Scenario parameters relative to base case

Parameter\Scenario	Open	Connected	Scattered	Notes
Connectivity				
▪ Networking	*Fast*	*Fast*	*Slow*	Growth rate of networked persons.
▪ ICT impact (manufacturing, services, ICT tech)	*Broad*	*Broad*	*Broad*	Translates growth in networked proportion of population into growth rates in specific sectors to which network sectors diffuse.
▪ Internet density multiplier	*High*	*Status quo*	*Low*	Adjusted separately for World, EU 27
Governance				

Parameter\Scenario	Open	Connected	Scattered	Notes
▪ Economic Freedom	*Grows*	*Grows*	*Slow*	
▪ Democracy	*Converge to middle level*	*Converge to high level*	*Status quo*	
▪ Freedom	*More free*	*Free*	*Status quo*	Multiplier on Freedom House's measure of freedom (FREEDOM) which sums civil and political scales and also changes endogenously.
▪ Protectionism in trade	*Very Low*	*Low*	*High*	
▪ Productivity growth of system leader (Manufacturing, Services, ICT)	*Status quo*	*High*	*Medium*	Adjusted separately for Manufacturing, Services, and ICT sectors. Changes diffuse to productivity growth other countries.
▪ Elasticity of MFP w.r.t. Health spending	*Status quo*	*Status quo*	*Low*	
Government expenditures Adjusted separately for Leaders (OECD) and Followers (Non-OECD)				
▪ R&D spending	*High for leaders; slow for followers*	*High*	*Slow for leaders; fast for followers*	
▪ Education spending	*Fast for followers; slower for leaders*	*High*	*Slower for followers; fast for leaders*	Educational spending is further broken out across three educational levels (primary, secondary, and tertiary).
▪ Health spending	*Low*	*High*	*Slight increase*	
▪ Economic Investment	*Low*	*High*	*Status quo*	
▪ Welfare spending (for non-OECD/unskilled)	*Low*	*High*	*Status quo*	Government to household welfare (non-pension) transfers for social welfare.
Firms/businesses				
▪ FDI	*High*	*Status quo*	*Low*	Foreign direct investment
Individual behaviour				
▪ Work life	*Decreased*	*Status quo*	*Increased*	Labour force multiplier on retirement age
Distribution of wealth				
▪ Income distribution	*More equal*	*Less equal*	*Less equal*	Domestic Gini.

Appendix D: Cases studies of policy frameworks in Japan, US, South Korea and the OECD

Japan

The Japanese government is currently conducting a major foresight exercise to develop its ICT strategy for 2025. Results are expected to come out towards the end of this year.

The only field where we do have some indication of future aspirations today already is in the context of Japan's New Generation Network (NWGN). NWGN is proposed as a clean slate network architecture with main protocols that may not be IP-based. It is intended to be designed flexible enough so that it can develop continuously over 50 to 100 years.(IT Strategic Headquarters, 2006 provides a good summary).

To the extent that, as some suspect, the new Japanese ICT strategy will build upon the relatively broad framework of Japan's ICT strategy 2006-2010, we outline this strategy (2006-2010) in the following. The strategy is structured around 3 policy areas: policies that seek the resolution of various problems arising from the pursuit of IT structural reform capabilities; policies concerned with the development of the foundation for the support of IT structural reform capabilities; and policies concerned with the international contribution to the rest of the world:

- Policies that seek the resolution of various problems confronting Japan through the pursuit of IT structural reform capabilities – including:
    - Measures using IT to resolve issues in health and the environment.
    - Measures designed to create a society in which people can live safely and securely
    - Measures to promote effective and meaningful activities by government, business, and individuals (such as e-government).
- The second category of policies concerns the development of the foundations for the support of IT structural reform capabilities and for the creation of the Ubiquitous Network Society – including:
    - Measures for the creation of an IT society with no disparities in information levels and for the advancement of ubiquitous networks.

  - Measures intended to create environments that allow for the safe use of IT.
  - Measures to promote human resource development that will support the foundations of the IT society.
- The third category of policies concerns international contributions through the transmission from Japan to the rest of the world of the results achieved through the other two policy categories – including:
  - Measures to enhance the presence of Japan in international competitive society.
  - Measures to make contributions to other Asian countries by providing problem-solving models.

In terms of implementation: Each policy initiative – falling under three main policy areas mentioned above – has a set of targets and 'key evaluation points' against which it will be evaluated. As an example under the 'realization of a safe and secure society' the policy targets include (among others):

- Reduce the number of traffic fatalities and serious injuries by deploying
- Cooperative Driving Safety Support Systems.
- Reduce the time from detection of traffic accidents to admission of injured persons at medical facilities.

The corresponding 'key evaluation points' are:

- The number of traffic accidents, serious injuries, and the rest sites.
- Automobile user satisfaction with Driving Safety Support Systems.
- The time from detection of traffic accidents to admission of injured persons at medical facilities.

South Korea

The Korean government does not have 2020 or beyond vision. The Korean government, however, came up with 3-year - 5-year plan for implementation.

Historical Background

The enactment of the Framework Act on Informatisation Promotion and the creation of the IPC in 1996 paved the way for the advancement of information technology nationwide. The Korean government formulated and carried out the First Master Plan for Informatisation Promotion in 1996, which reflected 10 key tasks for accelerating the advancement of information technology (Song, 2006).

In 1999, the Korean government launched Cyber Korea 21, the second master plan for informatisation promotion. Cyber Korea 21 envisioned the construction of a creative knowledge-based economy for the 21st century and proposed a number of strategies and policy tasks to be carried out by 2002. It contributed to the spread of the Internet and the promotion of the digital economy in Korea.

In 2002, the Korean government launched e-Korea Vision 2006 in response to the challenges of the new millennium, notably the globalization of the world economy and the rapid shift to a knowledge-information society. Its aim was to transform Korea into a global leader through the continued enhancement of broadband IT networks.

The Broadband IT Korea Vision 2007 announced in December 2003 highlighted the government's commitment to improve administrative services through the implementation of open e-government; strengthen national competitiveness by applying IT to industries; construct a broadband convergence network; develop new IT growth engines; achieve a GNI per capita of USD 20,000; and become a global leader by strengthening international cooperation.

The present system

The emergence of ubiquitous technologies prompted a revision of the Broadband IT Korea Vision 2007 into the u-Korea Master Plan in March 2006 (MIC, 2006). Laws on informatisation can be divided broadly into five categories according to their functions:

- The first category includes laws for building the infrastructure for an information society.
- The second category consists of laws supporting the revitalization of information services, including laws supporting informatisation of private and public services.
- The third category includes laws fostering and advancing the ICT industry, as well as laws for developing new growth engines.
- Laws creating an environment for fair use of knowledge and information are included in the fourth category.
- The fifth category includes laws for preventing all sorts of malfunctions and adverse effects of informatisation, including cyber crimes, the circulation of harmful information, the digital divide, invasion of privacy, and the like.

The significant ICT-related laws are the e-Government Act, Electronic Signature Act, Act on Managing Knowledge Information Resources, Act on Closing the Digital Divide, Act on Promotion of Utilization of Information and Communication Network and Data Protection, Telecommunications Business Act, e-Financial Transaction Act, and Act on Security of Personal Information Processed by Computers in IT Net-works.

Ambitions

The main ambitions of the u-Korea Master Plan can be divided into three broad classes: infrastructure ambitions, software ambitions, and dealing with challenges ambitions:

<u>Infrastructure Ambitions</u>

To achieve the vision of a ubiquitous network society where all objects are intelligent and networked to one another, the Korean government continues to enhance the country's IT infrastructure. In particular, the government has been pushing forward with policies and projects to construct:

- Broadband Convergence Network (BcN),
- Ubiquitous Sensor Network(USN), and
- to promote the spread of Internet Protocol version 6 (IPv6) (NIA 2007a).

The BcN is a next-generation network integrating communications and broadcasting, wired and wireless services, and voice and data services. The construction of the BcN is expected to enable the provision of broadband multimedia service to 10 million fixed-line subscribers at speeds of 50–100 Mbps, and to 10 million wireless subscribers at speeds over 1 Mbps by 2010.

The USN is an information service infrastructure through which sensor nodes are networked with each other to recognize, integrate, and process information on humans, objects, and environments, thus enabling all people to use the information at will, anytime, anywhere. To come up with practical service models and commercialize them, USN pilot tests are being carried out in food and drug management, airline baggage management, munitions management, and road facilities management, among others.

In a ubiquitous network society, personal computers (PCs), electronic appliances like televisions and refrigerators, handheld devices such as personal digital assistants (PDAs) and mobile phones, cars, street lights and buildings will be connected to the Internet. This poses the threat of Internet Protocol (IP) addresses running out. To prepare for this possibility, the Korean government has released the ‘Plan for accelerating adoption of IPv6’, which requires research networks to adopt IPv6 in 2008 and provide IPv6 as a test bed network to communications equipment vendors and Internet service providers (ISPs). By 2010 public sector networks and systems should support both Internet Protocol version 4 (IPv4) and IPv6. ISPs are expected to adopt IPv6 for their major transport network by 2010 and for all access networks by 2013.

Software Ambitions

Korea ranks high globally in most IT-related indexes except for software development where it is lagging. To create new markets and ultimately make the nation a software powerhouse, the government has been increasing demand for open source software (OSS) through large-scale public projects, and strengthening the production base of OSS through the revitalization of related communities.

Government efforts to encourage the use of OSS in the public sector boosted the growth of the OSS market from KRW 49 billion in 2002 to KRW 95.9 billion in 2006, representing an average annual growth rate of 18.3 percent. Linux has been used in building several administrative databases and it is now being adopted by the private sector, especially by dot-com companies like NHN Corporation (http://www.nhncorp.com, http://www.naver.com) and DaumCommunications (http://www.daum.net).

‘Dealing with Challenges’ Ambitions

The anonymity that the Internet makes possible facilitates communication among people, but it also has adverse effects such as verbal violence and defamation in cyberspace. To prevent these adverse effects and encourage responsible behaviour on the Internet, the Act on the Promotion of Utilization of Information and Communication Network and Data

Protection requires large private websites to include ways to track users by their national identity number.

Another social problem that has resulted from easy access to the Internet is Internet or online addiction. Internet addicts have difficulty controlling the amount of time they spend online, suffer withdrawal symptoms when away from the Internet, and are ultimately unable to engage in real life interaction and relationships. Internet addiction, which is also called pathological Internet use, is a problem that needs social attention because it can lead to criminal behaviour. In Korea, the K-Scale for the youth and A-Scale for adults have been developed to assess signs of Internet addiction.

A 2006 study involving 3,000 people found that 9.2 percent of those sampled were Internet addicts. In response, public agencies, including KADO, have been providing people with education and counselling services to prevent and/or treat Internet addiction. Meanwhile, as environmental pollution worsens, the environment is emerging as one of the biggest global issues. Global warming in particular is expected to have a serious impact on the global economy since an enormous amount of money is needed to fight global warming.

In Korea, President Lee Myung-bak has suggested a national vision of 'Low Carbon, Green Growth' as the country's contribution to the international campaign to respond to climate change while maintaining economic growth. Green IT is grabbing much attention in Korea. Furthermore, a lot of research is being carried out on how to reduce the energy consumption and carbon emissions of the IT sector itself and how to use IT to improve energy efficiency and realize low-carbon economic growth.

Canada

In Canada there is little discussion of an ICT strategy beyond the year 2010. In fact, many sources criticise the Canadian government for the lack of such a strategy.

A good indication for what a future ICT strategy might look like can be obtained from the recent report by the Industry Canada's Telecommunications Policy Review Panel.[195] The mandate of the review was "to review Canada's telecommunications policy framework and recommend on how to modernize it to ensure that Canada has a strong, internationally competitive telecommunications industry that delivers world-class services for the economic and social benefit of all Canadians."

The recommendations can be organised around five themes:

- Strengthen ICT Adoption by Canadian Businesses
- Strengthen ICT Adoption by Government
- Strengthen general ICT Adoption skills
- Strengthen ICT R&D
- Promote Security, Confidence and trust in an Online Environment.

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[195] Industry Canada (2006).

According to the Panel, the availability of advanced ICTs constitutes an opportunity for all Canadian business – in particular the small and medium sized ones (which still lag behind in ICT adoption).

Similarly, the Panel supports the idea that Canada has much to gain by way of their more effective adoption and deployment of ICTs for the delivery of public services, including the areas of health, education and emergency preparedness.

In terms of general ICT adoption skills "a variety of skills are needed for smart adoption of ICTs. Some of these are technical […], others are managerial […], still others are the skills that employees, students, consumers, citizens and end-users increasingly need to interact using ICTs with organizations, communities of interest and each other". The panel makes the case that the development of these skills should be another objective of a national ICT strategy.

Related to this, the Panel also argues that "without a strong national ICT R&D base, Canada will lack the people, ideas, and knowledge networks to effectively shape and implement ICT adoption strategies throughout the Canadian economy. The Panel also believes that, in the absence of a strong Canadian ICT R&D effort, Canada may find it increasingly difficult to position itself at the high-value-added, knowledge-intensive end of global and regional supply chains."

Finally, the Policy Review Panel makes the case for an increased awareness of the risks and vulnerability associated with ICT adoption. These include in particular:

- Risks threats to privacy,
- Safety, reliability and security of networks,
- Cybercrimes and
- Illegal content.

US

When it comes to USA, much is up in the air given transition to a new administration. Some indications/aspirations come from the official White House site: [196]

- The Recovery Act calls for a comprehensive plan for national broadband, and the Federal Communications Commission (FCC) is developing a plan due in February 2010. The Recovery Act also provides for $7.2 billion for broadband access, expanding computer centre capacity, and sustainable broadband adoption initiatives.
- The President appointed the first ever Federal Chief Information Officer to provide management and oversight over federal IT spending and nominated the first ever Federal Chief Technology Officer to provide vision, strategy and direction for using technology to bring innovation to the American economy.

[196] http://www.whitehouse.gov/issues/technology/

A clear strategy is unlikely to come out before the new positions (of the CIO and CTO) have been filled – and time for development of a strategy has passed.

The only area where we do have a good idea about future ambitions in the ICT field is in the context of the development of a new generation network – just as Japan. The initiative is called Global Environment for Networking Innovations (GENI). GENI is supported by the Directorate for Computer & Information Science and Engineering (CISE) of the National Science Foundation (NSF). GENI promises to support the experimental exploration of robust new networking and distributed systems architectures and services that will revolutionize computing. In particular, it challenges design assumptions of the internet and aims to deliver a new design that overcomes limitations of the current internet[197]:

- Making the future internet secure: worms, viruses, denial of service attacks raise concerns about massive collapse, due either to natural errors or malicious attacks. Trust in the internet is eroding. The next wave of computing devices (sensors and controllers) seems to reject the internet in favour of isolated "sensor network".
- Ensuring adequate levels of availability. In particular, able to meet the needs of society in times of crisis by giving priority to critical communications.
- Providing right economic incentives for economic investment and enhancement by the private sector.
- Making it more user-friendly, by introducing new design principles that make it easier for large network operators and consumers at home to set-up, identify failures or to manage.

The second motivation is that the future internet foster, rather than inhibit, emerging applications and technologies. To realise its potential, the future internet must enable and encourage:

- Mobility and universal connectivity, allowing any piece of information to be available anytime, anywhere.
- Availability of information online, hence meets commercial concerns, provides utility to users, and makes new activities possible.
- Smarter, safer, more efficient, healthier, more satisfactory sensor-based network
- Balances realisation of important social concerns such as privacy, accountability, freedom of action and predictable shared civil space.
- Seamless integration, where "computing" and "networking" will become a natural part of our everyday world not something we "do".

Unlike traditional network test-beds, GENI is conceives as a general purpose facility that places essentially no limits on the network architectures, services, and applications that can be evaluated. Future Internet research has attracted a lot of attention across the globe with a number of initiatives such as the Future Internet Assembly in Europe, GENI in the US

[197] Info source: http://www.nsf.gov/pubs/2006/nsf06601/nsf06601.pdf

and AKARI in Japan. A common theme is the requirement to adopt an all encompassing approach taking into account requirements and views from a number of angles: networking protocols, socio-economics, services, security, etc.

OECD

The OECD Seoul Declaration for the Future of the Internet Economy was adopted by 39 countries and the European Community on 18 June 2008. It outlines the basic principles that will guide further development of the Internet Economy. The Seoul Declaration stresses the vital role that Internet and ICT technologies can play to tackle new challenges such as an ageing population, environmental and energy concerns, the scarcity of raw materials, globalisation and regional imbalances.

Ministers and stakeholders considered social, economic and technological trends shaping the development of the Internet Economy and forged three broad principles that can provide an enabling policy environment for the Internet Economy:

- Convergence and NGN:
  - open, decentralised, interoperable, technical standards that contribute to innovation, interoperability, participation and ease of access.
  - Stimulate investment and competition within and across border
  - Ensure greatest practical national coverage and use
  - Encourage adoption of IPv6
- Creativity
  - Open environment that supports free flow of information, research, innovation, entrepreneurship and business transformation
  - Make public sector information and content accessible in digital format
  - Encourage collaborative innovation networks across stakeholder groups
  - Combine efforts to combat digital piracy with innovative approaches that provide creators and right holders right incentives
  - Encourage new internet-based models and social networks for the creation, distribution and use of digital content that fully recognise the rights of creators and the interests of users
  - Strengthen development of HR, further develop ICT skills and digital and media literacy
- Confidence and security
  - protect critical infrastructures
  - strengthen resilience and security of internet and related networked ICT systems
  - reduce malicious activity online through reinforced national and international cooperation

  - ensure the protection of digital identities
  - ensure consumer benefits from effective consumer protection
  - protecting minors when using the internet
- Truly global internet economy
  - e-inclusion/digital divide
    - support expanded access
    - enhanced services to people with disabilities and special needs
  - promote competitive environments for successful growth
  - Promote creation of local content and multi-language translations to improve economic and social inclusion of people
  - Facilitate introduction of internationalised domain names (IDN)
  - Increase cross-border cooperation of governments and enforcement authorities in the areas of improving cyber-security, combating spam, as well as protecting privacy, consumers and minors
  - Internet to tackled global challenges such as improving energy efficiency and addressing climate change

Appendix E: Cross cutting relevance of connectivity challenges

Three tables:

1. Table A: Connectivity challenges in relation to overarching policy priorities
2. Table B: Connectivity challenges arising across the EC
3. Table C: Indicative mapping of responses to connectivity challenges by DG.

Annex table 15: Connectivity challenges in relation to overarching policy priorities

Connectivity	Energy/climate	Lisbon agenda: macroeconomics, Innovation	Single market	Inclusion/, Empowermer
Safety	Better grid management	Standards, Self-correcting market mechanisms	Standards, stimulus to cross-border trade	Self-correcting market mechanisms
Integrity of data and communications	Management and security of power grid, CHP	Fighting bad connectivity, Data protection leading to business model development, greater competitiveness	Data protection, Balancing openness and privacy	Fighting bad connectivity, protection
Reliability	Better infrastructure, reliable power, better grid management	Better infrastructure, reduced infrastructure risk, greater reliance on connectivity/Internet leading (possibly) to collective management	Better infrastructure, Emerging services economy, End-to-end	Universal service (BB), Dependency on connectivity/Internet
Quality	Access to funding for infrastructure upgrades, Smarter grid; use of ICT for better matching supply and demand for energy in EU	Spectrum availability and usefulness Failed IT – lack of political priority, Competition policy/fighting lock-ins, Under-connection (network externalities), Access to funding for infrastructure upgrades; over-connection/responsibility	Enhance B2C and cross border connectivity, Smarter grid; use of ICT for better matching supply and demand for energy in EU, Expanded and harmonised spectrum availability, Emerging services economy	Spectrum availability, Competition policy/fightin lock-ins, Under-connectio (network externalities), Ac funding for infrastructure upgrades, Ageing populati
Ubiquity	Transport prevention, energy economies of scale, providing user information on energy use	Mobilising and stimulating investment in Europe's human and organisational capital, promoting collaborative innovation over 'weak ties' (people who don't usually interact)	Increasing the 'addressable demand' of innovative products, Under-connection challenge	
Affordability	Uptake and use, reduction of divides[198]	Reducing digital – and therefore economic – divides, stimulating domestic demand (and flexible labour supply)	Reducing eCommerce transactions costs, limits to self-correcting market mechanisms	
User friendliness	Increased uptake and use, providing user information on energy use[199]	Interoperability and standards, Competition policy/fighting lock-ins, Ageing population	Openness and reachability of name space, Interoperability and standards , Ensure cross border connectivity	Openness and reachability name space, Data protecti Ageing population
Sustainable	Optimising contribution of connectivity to environmental sustainability	Network structures , Business model development, Technical alternatives to regulation , Emerging services economy	Technical alternatives to regulation, Minimise anti-competitive behaviour	Access to funding for infrastructure upgrades

[198] Digital divides exacerbate other divides, including use of energy, which has been shown to increase overall consumption

[199] A recent study in Argentina) showed that providing this information (via connected networks) triggered increased energy saving in households

Annex table 16: Connectivity challenges arising across the EC

DG	Connectivity issues
DG COMP	Anticompetitive effects of 'network power,' vertical or combined market power, networked market definition Funding infrastructure investment Inefficient lock-in Standards and interoperability
DG ECFIN	Economic and societal connectivity
DG EMPL	Access to work, remote working Ageing population
DG ENTR	Standards and interoperability Spectrum availability Funding infrastructure investment Failed IT projects Governance of Network structures (Better regulation) Technical alternatives to regulation (Better regulation) Business model development Service economy Limits to self-correction (Better regulation)
DG INFSO	Limits to self-correction Under-connection Over-connection Network structures End-to-end principle Name and address openness Inefficient lock-in Raised profile of technical regulation Technical alternatives to regulation Privacy, trust, confidence Bad connectivity
DG JLS	Technical alternatives to regulation Privacy, trust, confidence Bad connectivity
DG TREN	Bad connectivity

	Regulation for cross-border connectivity
DG MARKT	Funding infrastructure investment Regulation for cross-border connectivity Service economy Standards and interoperability
DG REGIO	Funding infrastructure investment
DG Research	Standards
DG SANCO	Epidemiology, and spread of viruses through ‘bad connectivity Privacy, trust, confidence
DG Environment	Contribution to sustainability
DG DIGIT	Raised profile of technical regulation Regulation for cross-border connectivity
DG Relex/ DG Trade	Global reach and functionality

Annex table 17: Indicative mapping of responses to connectivity challenges by DG

Challenge	MARKT	REGIO	COMP	TREN	SANCO	RESEARCH
Standards	SME, innovation-friendliness	Appropriate standards for connecting regions to Single market	Possible pro- or anti-competitive aspects of standardisation, role of standards bodies	Interconnection and management standards for transport and energy networks	Data (esp. EPR) interchange standards	Link of RTD to standards
Spectrum availability	New business models	Local management, use of spectrum for economic development, public services	Wireless as competitor with wireline, cornering spectrum markets, foreclosure	Wireless enhancement to transport networks (smart roads, cars, wireless on trains, etc.)	Health impacts, remote monitoring	Compression technology
Network structures		Creation, impact of regional hubs	Bottleneck position as part of SMP test	Hubs and spoke, other architectures (lessons from SNA analysis of connectivity, compatibility of electronic, transport network structures)	Impact of healthcare connectivity structures (where data are collected, stored, etc.) on performance of healthcare systems.	Interaction of network structure, individual behaviour, overall contributions to policy
End-to-end principle	etc	etc	etc	etc	etc	Etc
Name and address openness						
Anti-competitive behaviour						
Limits to self-correction						
Under-connection						
Funding infrastructure investment						

Challenge	MARKT	REGIO	COMP	TREN	SANCO	RESEARCH
Failed IT projects						
Regulation for cross-border connectivity						
Global reach and functionality						
Contribution to sustainability						
Over-connection						
Business model development						
Economic and societal connectivity						
Bad connectivity						
Privacy, trust, confidence						
Technical alternatives to regulation						
Raised profile of technical regulation						
Inefficient lock-in						
Dependency						
Ageing population						
Service economy						