Research Policy 41 (2012) 1631–1642

Contents lists available at SciVerse ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

The unsustainable directionality of innovation – The example of the broadband transition

Inge Røpke*

Department of Management Engineering, Technical University of Denmark, Produktionstorvet, Building 424, 2800 Kgs. Lyngby, Denmark

ARTICLE INFO

Article history:
Received 8 January 2011
Received in revised form
24 November 2011
Accepted 7 April 2012
Available online 1 May 2012

Keywords:
Transition theory
Broadband
Green ICT
Selection environment
Energy consumption

ABSTRACT

Information and communication technology (ICT) can be seen as a general-purpose technology with wide-ranging socio-economic and environmental implications across sectors. ICTs also constitute a system of technologies with stronger internal links since the emergence of the Internet and broadband as a new information infrastructure. The new infrastructure has co-evolved with widespread integration of ICTs in everyday life, and consumer demand has been decisive for ICT innovation. This article explores the environmental directionality of ICT innovation and the broadband transition, focusing mainly on energy impacts. It is argued that much innovation tends to develop in an unsustainable direction and that public regulation falls far short of the challenge. Transition theory is applied to analyze the background for the unsustainable development and the reasons why environmental concerns do not figure more prominently in the broadband transition. Finally, it is discussed how the direction of ICT innovation could be influenced in order to realize more of the positive sustainability potential.

1. Introduction

Information and communication technologies (ICTs) have a long history in which the foundations were laid for separate industries such as telecommunications, recorded music, film, radio, television, and office equipment. In spite of this long history, the concept of ICT is of more recent origin in relation to the merger of technologies for communication, broadcasting and data processing. The basis for the merger was the emergence of the transistor and later the microchip, which made it possible to install an ever-increasing number of transistors in a very limited space. This miniaturization enabled the inclusion of advanced data-processing facilities for monitoring, management and manipulation in a multitude of products, as well as development of the general-purpose personal computer. Digitalization led to increasing intertwining between the different industries related to telecommunications, entertainment and office equipment, and the appearance of the Internet reinforced the process considerably. ICTs have developed into a cluster with large social and economic importance, and although Winston's account of the historical development of media technologies emphasizes that the present changes are far from being as "revolutionary" as the hype sometimes suggests, it is probably safe to say that the potential for future change related to ICTs is enormous. The Internet is at the core of the present ICT-related changes, and the establishment of high-speed networks is often seen as the basis for realization of the great potential for social and economic change related to ICT. As Melody puts it, the broadband as the new information infrastructure will be the most important public utility in 21st century economy (Melody, 2007).

How is this potential used in relation to the great challenge of transforming societies in a more sustainable direction? ICTs can be used in many different ways, and the different paths are decisive for the resulting environmental impacts. Already in the early phase of microelectronics and digitalization, much hope was attached to the potential for environmental improvements through ICT (Freeman, 1992), and surely, ICTs have contributed to such improvements in various ways – from environmental information systems to better management of production processes. Unfortunately, however, ICT also gives rise to considerable environmental costs, not least in relation to the integration of ICT in everyday life. Some have tried to assess the "net" environmental impacts of ICT, but this exercise is so complex that it is difficult to reach reasonable and useful conclusions (for a recent survey, see Erdmann and Hilty, 2010). It may be more useful to explore the environmental directionality of various kinds of ICT-related innovations and consider the conditions for promoting sustainable and discouraging unsustainable innovation.

The purpose of this paper is to contribute to the discussion on the environmental directionality of ICT-related innovations. Innovation studies often assume implicitly that innovations are socially beneficial, and they focus on how to stimulate economically successful innovation. The increasing importance of the environmental agenda, however, calls for more focus on the directionality of

* Tel.: +45 4525 6009; fax: +45 4593 3435.
E-mail address: inro@man.dtu.dk

0048-7333/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.respol.2012.04.002

innovations, including both the encouragement of green innovation and the discouragement of environmentally problematic innovation. The paper thus explores the following questions: What are the environmental implications of ICT innovation and the broadband transition? How are the environmental impacts influenced by public regulation? Why do environmental concerns not figure more prominently? And how could the direction of ICT innovation be influenced in order to realize more of the positive sustainability potential? ICT has many different environmental impacts, but this paper concentrates mainly on the energy impacts, which are more topical than ever due to the climate change agenda. Experience with regulation is extensive with regard to energy impact, and the data availability is good.

The paper is partly based on a previous empirical study on the use of ICT in Danish households and the related energy impacts (reported in detail in Røpke et al., 2010a,b), combined with studies of government and business reports, and participant observations from business conferences related to broadband development. In addition, the paper brings together three different sets of literature, which tend to develop in isolation from one another: economic studies on ICT, studies on ICT and the environment, and sustainable transition studies.

The paper starts by introducing different perspectives on the integration of ICT in the economy and everyday life. In particular, the meso-level perspective is elaborated, seeing ICTs as forming a cluster of technologies and industries that can be studied as a system. Then, Section 3 outlines the energy impacts of ICT-related development, and Section 4 highlights how public intervention deals with these impacts. Since energy regulation has not succeeded in curbing the growing ICT-related energy consumption nor in realizing the sustainability potential of ICT, Section 5 explores why environmental considerations do not figure more prominently in innovation processes. This section brings in transition theory to organize the discussion. The concluding section summarizes the results and discusses the conditions for promoting a more sustainable direction in innovations.

2. Integration of ICT in the economy and everyday life

The integration of ICTs in the economy, and the related innovative potential of the technologies, can be studied from three perspectives, which may also be considered as three 'levels': macro and industry levels, and in between a meso-level focusing on a cluster of industries. First, ICTs are generic or general-purpose technologies – in the sense that they can be widely applied and influence the economy as a whole: ICTs can be used for all kinds of activities that involve the acquisition, storage, processing, and distribution of information (Bresnahan and Trajtenberg, 1995; Steinmueller, 2007), and the technologies offer an ever-increasing acceleration of these processes (Hilty, 2008). The generic character of ICT and the economy-wide implications call for applying the perspective of techno-economic paradigms, as suggested by Freeman and Perez (1988), and for exploring the wide-ranging implications for economic growth across sectors (Jorgenson, 2001).

Second, ICTs play a particularly strong role for the industries from which the technologies emerged in the first place, such as various media and communication industries, and the transformation of each of these industries may be studied as separate transition processes (Winston, 1998).

Third, ICTs may be seen as forming a cluster or system of technologies and industries at the meso level (corresponding to the system level in the innovation typology of Freeman and Perez, 1988). The emergence of the Internet and the development of the broadband infrastructures strengthened the links within the cluster, and the ICT sector increasingly appears as a whole that is subject to political intervention. Fransman (2010) offers a system-level account of ICT, inspired by Schumpeterian evolutionary economics and motivated by an interest in exploring innovation processes as a basis for government intervention to increase competitiveness. He applies an ecosystem metaphor and describes the ICT ecosystem as a set of organisms that interact within an environment. The organisms comprise firms, final consumer–users and various non-firm organizations like universities, government research institutes, standard-setting bodies and policy-makers – all involved in interactions, competitive rivalry and cooperative symbiotic relationships, that are decisive for learning and innovation. The players are embedded in institutions, rules of the game, both at the national level and internationally, and the ICT ecosystem interacts with other sectoral ecosystems, like the financial services system.

Fransman argues that the ICT ecosystem is undergoing radical change, largely as a result of the evolution of the Internet, which began to be widely diffused from around 1995. The Internet has transformed its parents, telecoms and computers, and added complexity to the sector by incorporating and transforming previously unrelated sectors such as media into the ICT sector. New groups of key players have been created, such as Internet content and applications providers, and new forms of consumer interaction have emerged. The new ICT ecosystem can be conceptualized as a layered system, which is defined at the same time by a technical architecture and by economic-institutional relationships. In a simplified model, Fransman identifies four layers that include both objects and actors:

1. Networked elements and the providers of these items: telecom equipment, computers, consumer electronics, intermediate goods, and the software needed to run the products.
2. Communication and content distribution networks and the network operators: the creation and operation of mobile, fiber, copper, cable, and satellite networks – networks that have become increasingly intertwined since the 1990s.
3. Contents and applications and the providers of these outputs: contents and applications for final users include, for instance, textual information, music, video services, electronic commerce, email, and Voice-over-IP. In the simplified model, this layer includes functionalities such as search and navigation software needed to access the contents.
4. Final consumption and consumers.

Fransman emphasizes that the ecosystem is restless, with changing boundaries between the layers influenced by innovation, market development and regulation.

From a consumer perspective, the strong connection between ICT and media is reflected in the partial dissolution of the traditional distinctions between different kinds of equipment: consumer electronics for entertainment (television, radio, music, games), telephones for communication, and equipment for administrative tasks like word-processing and calculations are increasingly being merged, and they are often bought from the same shopping outlets. ICTs are increasingly perceived as a category of consumer goods, and they play a particularly prominent role in entertainment practices and practices with a large element of communication (like keeping in touch with family and friends). Simultaneously, the interpretive flexibility of the 'new' ICTs is very wide, and the core technologies of computer, mobile phone and Internet are open for integration into a broad variety of everyday practices. The increasing integration of computer and Internet across everyday practices is highlighted in a qualitative study of ICT use in Danish households, considering 48 activities organized into 10 groups: communication, entertainment, information, purchase and sale, work at home, education, hobbies and volunteer work, administration and finances, domestic work and management of the dwelling,