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cyberscience

Research in the Age of the Internet

Chapter 1

CONCEPTUAL FRAMEWORK: DEFINITIONS AND A MODEL

Austrian Academy of Sciences Press
Vienna 2003

Submitted to the Austrian Academy of Sciences on 10 April 2003
by Gunther Tichy, member of the Academy

British Library Cataloguing in Publication data.
A Catalogue record of this book is available from the British Library.

ISBN 3-7001-3188-7

Austrian Academy of Sciences Press
Tel. +43-1-5129050-3405, Fax +43-1-51581-3400,
Postgasse 7, A-1010 Vienna
Email: verlag@oeaw.ac.at
http://hw.oeaw.ac.at/cyberscience

Layout, cover & type-setting: Manuela Kaitna, A-1080 Vienna
Printed and bound in Austria by Manz Crossmedia GmbH & Co KG, A-1051 Vienna

DETAILED LIST OF CONTENTS

1 Conceptual framework: definitions and a model ... 21
1.1 What is cyberscience? ... 21
1.1.1 Cyberscience as an encompassing phenomenon ... 23
1.2 Modelling ICT impact on academia ... 26
1.2.1 The basic model ... 29
1.2.1.1 Information and communication technologies ... 30
1.2.2 Scholarly communication and its dimensions ... 31
1.2.2.1 Functions of the publication system ... 35
1.2.3 The diffusion of ICT in the scholarly communication system ... 37
1.2.3.1 Institutional factors ... 38
1.2.3.2 Technical and functional factors ... 41
1.2.3.3 Actor-related factors ... 43
1.2.3.4 The intervening factors at work ... 45
1.2.3.5 Qualitative trend extrapolation ... 47
1.2.4 Impact assessment ... 50
1.2.4.1 Changes of the scholarly communication system ... 52
1.2.4.2 General impact on academia ... 59
1.2.4.3 Impact on research substance ... 60
1.2.5 The complete model ... 63

"To develop a precise concept and operational definition of a complex social macro-phenomenon that is only vaguely identified at first and cannot be observed as a unit, is a highly challenging task; (...)"
(Mayntz 2002, 15)[38]

1 CONCEPTUAL FRAMEWORK: DEFINITIONS AND A MODEL

This chapter sets the terms of reference for my analysis. It defines the main concepts and notions[39], outlines how the basic elements are connected, and describes the intervening variables. At the same time, it may be read as a guide to the rest of the study.

1.1 What is cyberscience?

During the last decade, we have been flooded by various expressions with prefixes abbreviating "electronic", such as "E-" (e.g. "E-mail") or "e-" (e.g. "e-conferencing") or just a simple small "e" immediately before the main word (e.g. "eCommerce"). Similarly, the prefix "i" or "i-" as an abbreviation for "Internet" (e.g. "iContent") or for "intelligent" (as in "iForms") and likewise "o" or "o-" for "online", as well as the use of the special character "@", originally defined to distinguish between the user name and the server in E-mail addresses became popular (e.g. "br@instorming"). Wherever the new media and, in particular, the Internet is involved, a number of other letters such as "i" or "w" in a similar form, i.e. with a thin line around it are also used. Also "tele" can be seen quite frequently (like in "teleteaching"), meaning that it has to do with an activity performed at distance. Finally, the prefix "cyber", as an abbreviation of "(related to) cyberspace"[40], is similar widespread (e.g. "cyberlaw"). While these prefixes are often used just to let something old look more modern (in particular in advertisement), their use can be justifiable in terms of writing economy, i.e. with a view to abbreviate a whole concept. It is this latter

[38] Original in German, unpublished translation by R. Mayntz, communicated to this author.

[39] For descriptions and definitions of the technical key terms, such as E-journal, groupware or knowbot, please refer to chapter 2. Key conceptual terms are defined in this chapter and can also be found in Annex VI.

[40] The notion of "cyberspace" was first used in the (first so-called "cyberpunk") novel "Neuromancer" by William Gibson (1984): "'The matrix has its roots in primitive arcade games,' said the voice-over, 'in early graphics programs and military experimentation with cranial jacks.' On the Sony, a two-dimensional space war faded behind a forest of mathematically generated ferns, demonstrating the spacial possibilities of logarithmic spirals; cold blue military footage burned through, lab animals wired into test systems, helmets feeding into fire control circuits of tanks and war planes. 'Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding...'" (quoted from project.cyberpunk.ru).

purpose which let me introduce the notion of "cyberscience".[41] It will be used to designate the application as well as (potential) future development of information and communication technologies and services in academia. As opposed to "traditional" science, which does not use networked computers, I define for the purpose of this study

> "cyberscience" as all scholarly and scientific research activities in the virtual space generated by the networked computers and by advanced information and communication technologies, in general.

Just as cyberspace means "the virtual space created by electronic networks" (Gresham 1994, 37), cyberscience is what researchers do in the cyberspace, i.e. everything related to academia which takes place in this new type of space. Traditional academics either travelled in "thought spaces" or in real places. Cyberscientists, by contrast, spend a lot of time not only in these, but also in new virtual spaces. Information rooms spread out before them by online databases; chat rooms or discussion lists where they meet and communicate electronically with fellow researchers; digital libraries which deliver documents in bits and bytes; or, to name just one more example, virtual institutes which enable collaboration among researchers spread around the globe. Cyberscience technologies help to transcend real space. It is this strong relationship between these technologies and space which makes it advisable not to use just the prefix "e" for electronic, like in "eScience".[42] The connotations of "cyber" are more appropriate in our context since cyberscience is about more than electronic ways of doing science.[43]

Furthermore, the notion of cyberscience – and hence this study – does not encompass all aspects which have do to with the use of electronic means. In particular, we are not talking here about the use of stand-alone computers, that is not about the computer as a "tool" for modelling or computing or other forms of non-networked data production and processing such as artificial intelligence. While these aspects are certainly relevant and we shall come across them in some circumstances (e.g. when I discuss whether cyberscience has brought about new subjects in research or new methodologies like distributed computing, see 10.2), they are, nevertheless, not the focus of this study.

[41] To my knowledge, the term "cyberscience" has been used in academic research so far only in a paper by Wouters (1996), in a brief article by Jochum/Wagner (1996), in a short chapter on "a day in the life of a cyberscientist" by Thagard (1997b) and, since 1999, by this author. A session organised by P. Wouters at the 2000 4S/EAAST conference in Vienna was also called "Cyberscience" (<Cyberlink=20>). It is, nonetheless, frequently used in the Internet for a variety of purposes. A simple "GOOGLE" search counted in April 2002 over 4,600 hits. The term is used mainly by commercial enterprises to praise their products, e.g. software and publications. There are also so-called information gateways of this name and E-magazines on future technologies, sites with 3D images of latest research as well as a number of school sites. For a few examples, see <Cybercategory=55>. Meanwhile, the notion also triggers into journalism, although with a less precise meaning (e.g. Bernhofer 2001).

[42] The notion "e-science" is used, among others, by the European Commission in the context of the high-speed research network development activities (European Commission 2002, 6).

[43] Similar, "telescience" (as used by Carley/Wendt 1991; Walsh 1997; Lievrouw/Carley 1991) and "tele-communicative science" (Stichweh 1989, transl. MN) are too narrow as my subject is not only about doing things at distance, but for instance, even with local people next door in a new mode. The point is that the new science is taking place in a new space, cyberspace, and not (only) in real places, which can be reached, via telecommunication. Another, much too narrow notion in this context, put forward by (Lewenstein 1995), is "E-mail science". The most recent addition to this Babel of expressions is "digital academe" as used by Dutton/Loader (2002); they understand academe, however, in a much narrower sense as I do here in this study, namely focussing particularly on higher education and learning, not on science and research.

Neither do we look at the Internet as a research object in itself, e.g. in political science, sociology, cultural studies or IT studies – although the very existence of these new research topics is certainly a direct consequence of the advent of computer-mediated communication (CMC) in academia and elsewhere. Cyberscience is not the study *of* the cyberspace but science and research *in* cyberspace or, termed differently, under cyberspace conditions.

In other words, what I call cyberscience here is mainly the use of CMC over computer networks (Walsh/Roselle 1999, 50). Winiwarter (2000, 10) proposes to differentiate between, on the one hand, CMC, i.e. discussion forums, newsgroups, E-mail, online conferencing etc.; and, on the other hand, what she calls computer mediated information (CMI), i.e. homepages, bibliographical and other databases or E-journals. There are, however, strong arguments to consider scholarly publications as part of the communication process between researchers (see 1.2.1.1). Therefore, this distinction does not seem to be helpful since, E-journals, especially in their novel interactive formats, are then part of both CMC and CMI.

1.1.1 Cyberscience as an encompassing phenomenon

Before we go into the details of the study of the consequences of ICT in academia in the next chapters, it will be useful to show that there are manifold and comprehensive changes taking place on the way from traditional to cyberscience. ICT affects virtually all aspects of scholarly activity. It has already put its stamp on the basic framework conditions of research:

> "The scientific process encompasses a wide range of technical, social, and procedural activities, each of which involves information – information is collected, combined, analyzed, derived, discussed, and distributed. Some, if not all, of these activities may and often do benefit from the application of computer and networking technology." (Computer Science and Telecommunications Board 1993, 5)

With a view to exploring and substantiating this general statement, we need to categorise types of scholarly activity. Seen from a procedural viewpoint, we may distinguish knowledge production (including information gathering, as well as data production, analysis and management) from knowledge processing, i.e. scholarly communication (knowledge representation, discourse, evaluation, and co-operation); and knowledge distribution (publication, implementation and teaching). As regards the institutional setting, scholarly activities need technical equipment and organisational set-up. See Figure 1-1 for an illustration.

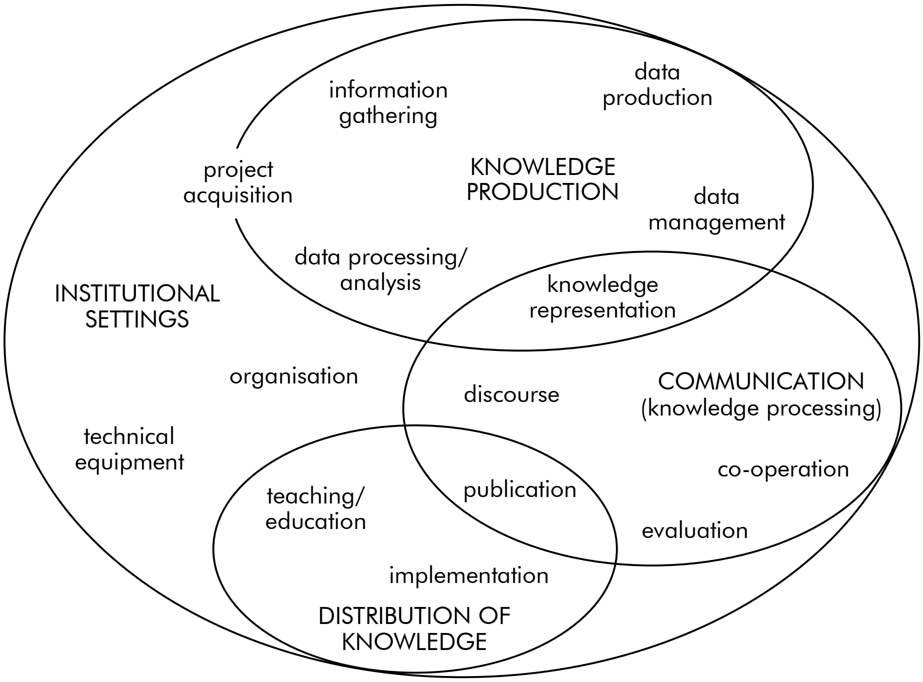

Figure 1-1: Types of scholarly activities and framework conditions

Note that some types of activities are part of more than one group. “Publication” is both about distributing knowledge outside the research community and about communicating knowledge within the academic circles. ”Knowledge representation” is both the final and an interim state of knowledge production and part of communication or knowledge processing. Also, project acquisition has organisational as well as production-related aspects.

If we take this classification of scholarly activities and framework conditions as a basis and compare what tools a traditional scientist and a cyberscientist have at hand in the various categories, we find that cyberscience is affecting all of them. The following Table 1-1 highlights this. Note that for illustrative reasons, I also included a number of tools related to the stand-alone computer, which are, strictly speaking, not part of my definition of cyberscience above. All “cybertools” and “cyberactivities” will be presented in more detail in chapter 2.

Table 1-1: Changes in academia on the path to cyberscience

		Technical-organisational transformation: "Traditional" science →			Cyberscience
institutional set-up	Organisation	Traditional institute; guest researchers		Telework	Virtual institute
institutional set-up	Technical equipment	Typewriter; telephone; library	Stand-alone PC; fax	Internet connection	Multimedia PC; access to data networks
institutional set-up / knowledge production	Project acquisition	Face-to-face/by letter/ telephone negotiations		E-mail exchange	Electronic procurement
knowledge production	Information gathering	Libraries; personal conversations	Offline databases	Online databases; link collections; discussion lists	Digital libraries; knowbots
knowledge production	Data production	Interviews; experiments	Electron. text analysis; simulation/modelling	Internet surveys	Distributed computing; virtual reality
knowledge production	Data management	Card files; lists	Hypertextual card files; databases		Networked card files; de-central databases
knowledge production	Data processing/ analysis	"With paper and pencil"	Electron. data-processing; expert systems	Modelling; simulations	Artificial intelligence
knowledge production / communication (knowledge processing)	Knowledge representation	Linear texts	Electron. text-processing; databases	Multimedia; hypertexts	Hypertext-databases
communication (knowledge processing)	Co-operation	Letters; telephone; personal meetings	Exchange of electron. Manuscripts	E-mail; de-central assembly of databases; software sharing	Groupware
communication (knowledge processing)	Discourse evaluation	Conferences; seminars; conversations (pers./tel.)		E-mail; discussion lists; skywriting	Online conferences; internet chatting
communication (knowledge processing) / distri-bution	Publication	Print media	Submission of electron. Manuscripts	Parallel publication in WWW; E-pre-prints	Pure E-publications; "net of knowledge"
distri-bution	Teaching/education	Traditional teaching (seminars, lectures)	Correspondence courses	Multimedia manuals	Virtual university

To be sure, I do not argue here that those further to the right will necessarily substitute the phenomena further to the left in this table. Whether or not they do, is a central research question to be tackled in the rest of this study. The purpose of this visualisation is to show that we find cyber-applications in all lines of the table, i.e. in all areas of scholarly activity plus in all types of framework conditions mentioned above.

For instance, the distribution of academic knowledge through traditional teaching in the classroom in seminars and lectures still takes place. Books and hand-made copies of scholarly articles still play an important role. However, what has started as “correspondence courses” (e.g. in Britain’s Open University[44] or Germany’s Fernuniversität Hagen[45]) has meanwhile been enhanced by multimedia courseware, that is either on CD-ROM or accessible via the Internet. There are already many examples, mainly in the US, of online courses for students not present on campus. In data-management, databases are now available while until recently, various lists on paper and card files dominated the offices of researchers. The early databases were all local on stand-alone computers, but today, they are accessible online and may be filled co-operatively by de-centrally located researchers. Also the good old card files recently went online in a new hypertext-database format and might soon become accessible in networks. Even in project acquisition, the traditional means of phone-calls, personal meetings and paper forms, filled in on a typewriter, are about to vanish. Already, many of the negotiations may take place by E-mail and there are examples of electronic procurement sites where researchers have to fill in web forms instead of sending them by mail.

It has become obvious by now that the advent of information and communication technologies has the *potential to affect almost every aspect of academic activity* (Nentwich 1999a). This is the starting point of this study. The main question to be tackled is how exactly ICT will impact on academia. In the next section, a framework is presented which models the routes of impact and the various intervening factors to guide the research presented in the subsequent chapters.

1.2 Modelling ICT impact on academia

> “Theoretical eclecticism, i.e. the parallel use of different area specific theories, seems to be inevitable, if not the only successful way for a social science that does not merely talk about basic principles, but wants to explain social macro-phenomena.”
> (Mayntz 2002, 40)[46]

The basic aim of this study being five-fold, it cannot be elaborated in a consecutive but only in an integrative way, as outlined in the introductory chapter (section 0.2, cf. Figure 0-1). Given this complex task, a number of academic fields or research streams have to be taken into consideration. In particular, the approaches of technology assessment; diffusion research; communication science; and sociology of technology and science (STS) inform this study and will hopefully be informed by it. The following Figure 1-2

44 <Cyberlink=477>.
45 <Cyberlink=800>.
46 Original in German, unpublished translation by R. Mayntz, communicated to this author.

shows how these circles of thought overlap. At the intersections, we find the most important tasks of this study (see labels *in italics*). Hence, only a combination of these four approaches is adequate to our subject matter.

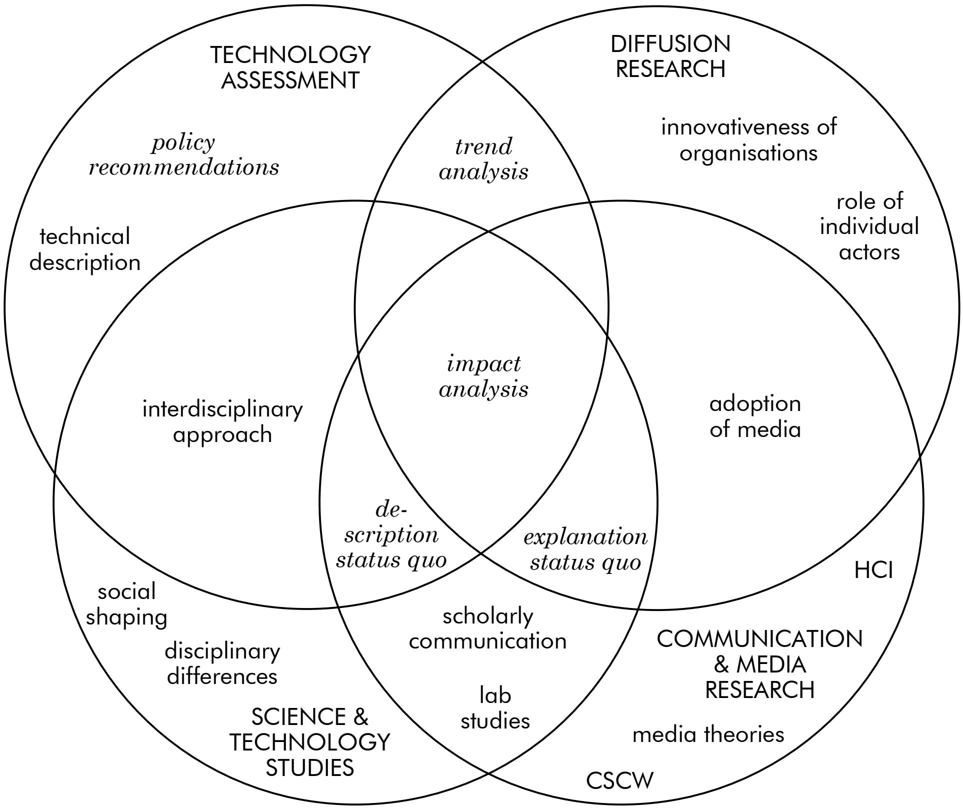

Figure 1-2: Four overlapping circles of thought informing this study

In the following, I shall briefly review these four research traditions. How they can benefit this study will be explained and incorporated in the rest of this chapter, at the appropriate places.

Diffusion research is interested in how technological (or other) innovations are implemented (or not) in a social system, including organisations (Rogers 1995).[47] At the heart of the analysis are the innovation-decision process and the conditions for a successful innovation process. Hence this stream of research contributes to an explanation of the status quo in any given situation of a diffusion process. The main focus is on individual actors (users), and their behaviour and attitudes. While most diffusion research analyses past innovation processes without dealing with long-term consequences, some also includes trend and impact analysis.

[47] On the diffusion of the telephone, see Rammert (1990), on the diffusion of the Internet, see Rogers (1995, 315 ff.).

Communication and media research, in turn, is an even wider field, including mass media research; the rather technically oriented communication science; social science approaches as well as the humanities, in particular cultural studies; both more empirically informed and more theoretically oriented research (Jensen 2002a). Media theory tends to argue on a meta-level of great steps in the evolution of dominant media use and its overall impact on society (Meyrowitz 1994; see also McLuhan 1962; 1964). A sub-field deals with scholarly communication in particular (Lievrouw 1988). This field includes both quantitative "artefact" and user studies (bibliometrics, scientometrics, surveys), network studies (recently with a focus on electronic media: Treloar 1998; and Heimeriks/van der Besselaar 2002) and so-called "lab studies" (with extensive fieldwork). The latter are also an important research field in the third circle of research traditions in Figure 1-3. Finally, there is also research in the adoption and use of media in various contexts (e.g. Scholl et al. 1996 on computer use in universities). And there is specialised research in computer-mediated communication (CMC, e.g. Walsh/Bayma 1996) as well as in computer-supported co-operative work (CSCW)[48] and in human-computer interaction (HCI)[49] that will inform this study.

Science and technology studies approaches our subject (in the wider sense) from a variety of angles (cf. already 0.1.2). While much work done in STS is interdisciplinary in nature, the field is dominated by sociologists from all types. Those more interested in the science side look at differences among the academic disciplines (e.g. Becher 1989), or study how scientific knowledge is produced (e.g. Knorr Cetina 1999) and how scholarly communication functions (see above). Technology studies in particular are interested in how technologies have evolved and what factors have shaped them. A number of different analytical traditions may be distinguished, such as social shaping of technology (SST, e.g. MacKenzie/Wajcman 1988; Kling/McKim 2000), social construction of technology (SCOT, e.g. Bijker et al. 1987; Klein/Kleinman 2002), actor network theory (ANT, e.g. Law 1992; Kling et al. 2000) and actor-centred institutionalism (Scharpf 1997; Schneider/Mayntz 1995; Schmidt/Werle 1998). Common, at least in principle, to all these approaches is that, first, technologies are co-shaped by "the social", the institutional framework, and the various actors; second, that technology is conceptualised as non-deterministic, that its effects cannot be explained solely by looking at the technology itself.[50] This study shares these basic assumptions. It needs to go beyond them, however, in so far as it is less interested in past developments than in looking at impacts and future trends.[51]

Technology assessment (TA) is the most practically-oriented and least "scientific" of the "circles of thought" under consideration in Figure 1-2 (cf. already 0.1.3). TA specialises in the impact assessment of technologies and will therefore guide this study in many respects (Porter et al. 1980; Bröchler et al. 1999). As it aims at providing policy recommendations in a given situation, an extended description of the technological status quo and its trends is typically confronted with the present and likely future societal situation in order to assess the impacts. This encompassing and interdisciplinary approach forms the basis of my approach here.

48 <Cyberlink=904>.

49 <Cyberlink=903>.

50 I do not, however, believe that it is mainly the changing needs of the society or culture at large that have produced the new media (Hartmann 2002). Rather, I conceptualise the technological development as partly independent from and partly shaped by the social.

51 Similar Kling/McKim (2000).

However useful all those approaches may be, there is, in the present research literature, no concept specific enough to satisfactorily grasp the phenomenon analysed in this study. At least, there are a number of starting points such as those just outlined that will guide my own analytical considerations. Beyond this basis, we have to develop a framework powerful enough to combine the dynamics of ICT, the special characteristics of academic communication and its ongoing changes and, finally, the relationship between the former two and the substance of research. For these ends we need, first, a conceptual framework for describing the scholarly communication system (1.2.2). Second, we need to get hold of the factors that have influenced the evolution from the traditional, non-ICT-based communication system to the present interim status quo, and which are deemed to play a role on the future path to cyberscience as well (1.2.3). Finally, we need a conceptual framework linking the observed changes to an assessment of the impacts on the scholarly communication system, in general, and on the content of research, in particular (1.2.4). To begin with, I shall present the basic model (1.2.1) to be detailed in the subsequent sections.

1.2.1 The basic model

On the way towards conceptualising the impact of ICT on academia, my initial observation is that information and communication technologies (whether new or traditional) cannot directly affect academia as a whole, nor the substance of research in particular. They may do so only indirectly, either via influencing the scholarly communication system (SCS) – computer mediated or facilitated communication (CMC) – or through changes in the new research tools, i.e. computers computing models, artificial intelligence (AI) etc. This study focuses on communication, not on tools.[52] The core of this research therefore links ICT to three interrelated elements (cf. Figure 1-3 below). A rounded corners box, labelled "changing scholarly communication system" contains my central ("change") model of the evolution of the traditional SCS to the future state of cyberscience (this will be detailed in 1.2.3). An ellipse labelled "impact on academia at large" represents the effects these changes have on scholarly communication in particular, and the whole communication-related structure of academia, at large. A second ellipse stands for the "impact on substance". How I conceptualise the impact of the changes of SCS on academia in general, and on substance in particular will be detailed in section 1.2.4. The following Figure 1-3 outlines the basic elements of this "impact model", which will be specified in detail in the following sections.

[52] For how I define ICT in my context, see just below 1.2.1.1. I would expect that a convincing answer on the question how information technology as a research tool is affecting research involves a different methodological approach.

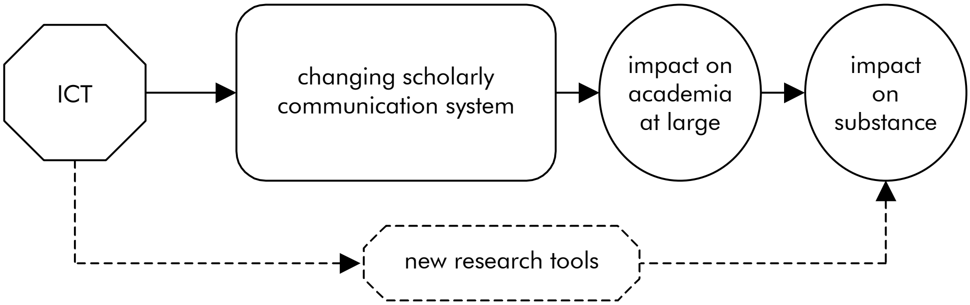

Figure 1-3: The basic model of the impact of ICT on academia ("impact model")

1.2.1.1 Information and communication technologies

The advent of the networked computer has considerably changed the number and types of ICT available for researchers. Not so long ago, the phone and later the fax were the only means of distant communication among scientists apart from letters and formal paper publications (journals, books). Only the last two decades have seen the development of: the transfer of digital files via E-mail, remote access to documents and databases, distant co-operation using sophisticated groupware applications with chat and desktop sharing, video-conferencing, E-journals and hypermedia applications.

The term "information and communication technologies" often comprises not only the analogue or digital transmission of data to connect people to people and to machines, but also the machines (in a wider sense) which process the information themselves (computers, instruments, software, databases). Here I shall focus on the subset of *communication technologies in a narrower sense*, in particular on the Internet as the main novel technology. Note, however, that other subsets of ICT – the "research tools"[53] – also affect the outcome of research activities. "Research tools" are the tools to treat the research questions. Consider the potential influence of expert systems, artificial intelligence (AI), simulation or, more generally, all types of programmes running on stand-alone computers, i.e. computers without communicative links. As already noted above (fn. 52), this aspect, is worth another study (therefore, in Figure 1-3, this route of impact is presented with dashed lines only). I, nevertheless, deploy the term ICT here, first, because it is a generally used notion and, second, because information technologies in a stricter sense are increasingly inseparable from communication technologies in a stricter sense (consider, for instance, remote access to distributed databases – a people-to-machine communication). While excluding the impact of IT as research tools, I include certain aspects of machine-to-machine communication since "intelligent agents" or "knowledge robots (knowbots)" may become active in the network for their principal agents, the researchers, with a view to, for instance, gather information.

[53] They are sometimes, but not always, depicted by the term "information technologies" (IT).

ICT
- Information technologies (computers, AI, databases, ...)
- Communication technologies (networked computers)
  - People-to-people
  - People-to-machines
  - Machines-to-machines

Overview 1-1: Information and communication technologies

Although ICT are constantly developing and changing, they are set as the main independent variable for the purpose of this study. The basis of this study is therefore an in-depth analysis of the independent variable and its evolution over time (chapter 2). The analysis, however, takes these changes into account. Technology can also be viewed as a dependent variable as it is *socially shaped*. Which technologies become further developed and get used not only depends on the characteristics of the technologies, but also on the nature of the social groups that are using them and for what purposes.[54] The model outlined below covers the influence of functional, actor-related and institutional factors on the move from 1^{st} to 2^{nd} generation cyberscience ICT (1.2.3).

1^{st} generation ICT are those tools which are not only available today, but are also used wide-spread in most disciplines, that is in particular E-mail, bibliographic databases, (conservative[55]) E-publications, WWW homepages, link collections etc. By *2^{nd} generation* tools I understand those which are presently being developed and experimented with only on a limited basis and which may gain influence soon, in particular video-conferencing, multimedia E-publishing, groupware, semantic web etc.[56]

1.2.2 Scholarly communication and its dimensions

Among the various types of scholarly activities (cf. Figure 1-1, above page 24), scholarly communication holds a central place and is linked with the two other main areas, namely knowledge production and distribution of knowledge. Scholarly discourse and co-operation would be unthinkable without communication. Publications can be defined as the products of scholarly communication. However, even knowledge production involves a good deal of communication, namely communication with the object of science (see below a). Furthermore, the distribution of knowledge is inherently a communicative endeavour, as are project acquisition and certain aspects of the organisation of science and research (academia as a network of communicating people with different specialisations). To a very large degree, *science and research is communication.*

[54] Similar to here Walsh (1996, 361); cf. for instance the contributions in Mackenzie (1988) on the social shaping of technology.

[55] In this context, "conservative" means that the E-publication do not feature multimedia, hypertext etc. (as discussed in 6.2), but are mainly online "clones" of what is still or previously was available in print.

[56] See chapter 2 for a detailed description of these tools.

For the purpose of this analysis, I therefore define scholarly communication in a very broad sense as *all communication involving at least at one end a scholar, whatever the medium*. This section explores the various dimensions and characteristics of scholarly communication. Analytically, we can distinguish (a) partners, (b) means, (c) properties and (d) functions of communication. The purpose of the following discussion is to set the terms of reference for the subsequent analysis.

(a) *Communication partners*: With Gibbons et al. (1994, 36ff.) I distinguish between three layers of scholarly communication: communication with the object of research, with other researchers and with the public. Researchers communicate, first, with their research objects (their data, their human or animal subjects etc.). A sociologist may interview or survey a group of people, an astronomer may look through a telescope, a biologist may use a computer tomograph to observe cells and an economist may query a database of economic time series. While the interviewing sociologist actually communicates in a traditional fashion, the three other scientists "communicate" in a metaphorical sense with their research objects. All of them, however, ask questions and get answers. Second, researchers communicate among themselves. We may distinguish between four groups of communication partners: the local colleagues at the research lab or institute (including the librarians), both remote and local co-authors or project collaborators, the members of an extended research group (i.e. people sharing a particular common research interest and occasionally working together and sharing information) and finally the scientific community at large. On the third layer, researchers also communicate – some more, some less – with the public at large, either directly or via the media. Furthermore, researchers communicate with ordering parties in case they need extra funds for carrying out the research and in case they prepare expert opinions (project acquisition and communication of results). This variety of communication partners can be summarised as follows:

Communication PARTNERS in academia

1st Layer: Object of research

2nd Layer: Other researchers (and research-related staff)

- Local colleagues
- Librarians
- Co-authors – project collaborators (local/remote)
- Extended research groups
- Scientific community at large (remote)

3rd Layer: External world

- Ordering parties
- The media
- The public at large

Overview 1-2: Communication partners in academia

(b) *Communication media:* Talking about the second and third layers only, we may further distinguish between various media of scholarly communication. Research communication is a combination of media of all three degrees as distinguished in communication research (Jensen 2002b): first degree, in particular speech; second degree, technically reproduced or enhanced forms of representation, e.g. written text, radio; and third degree, that is the "digitally processed forms of representation and interaction which reproduce and recombine previous media on a single platform" (ibid., 4), in particular the networked computer. For the purpose of focussing on the main media used in research, I distinguish between conversation, correspondence and publication. Researchers talk bilaterally, in small groups and in seminars, workshops and conferences. Conversation is either face-to-face or uses some form of ICT (e.g. the phone or, more recently, video-conferencing tools or Internet chat). Writing takes two basic forms: on the one hand, informal or formal correspondence via letters and short messages (in paper or electronically transmitted); on the other hand, formal publication in a variety of formats (either print or, more recently, in electronic formats).

MEDIA of academic communication

- *Conversation*
  (face-to-face, phone, internet chat, video-conferencing)
- *Correspondence*
  (letter, fax, E-mail)
- *Publication*
  (traditional publications {journals, newsletters, books}, E-journals, E-prints)

Overview 1-3: Media of academic communication

(c) *Communication properties:* All scholarly communication has a number of properties. First, we may distinguish between synchronous (immediate) communication media, i.e. those which require the simultaneous activity of the communication partners (e.g. a telephone conversation), and asynchronous (indirect) media which do not require simultaneity (e.g. a letter, but also leaving a message on an answering machine).

Note that this property does not coincide with the distinction between media allowing for local or for distant communication. Here I differentiate whether the communication partners have to be present at the same spot, or not. There is local-synchronous (e.g. in a research seminar), local-asynchronous (e.g. via a blackboard), remote-synchronous (e.g. a phone call) and remote-asynchronous communication (e.g. a letter).

Another property is speed. There are fast and slow media. Communicating a research result through the publication of a journal article, for instance, is rather slow. Distributing a research note via an E-mail discussion list is fast, as is giving a talk at a conference. We measure speed by the time the content of the communication needs to reach the addressee.

Furthermore, we can distinguish between informal and formal scholarly communication. While the first may take place on the phone, in the cafeteria, in the breaks of conferences, at workshops or, more recently, in Internet chat rooms or E-mail discussion lists and newsgroups, the second is – in varying degrees – more formalised. It takes place in academic journals, including their "letters to the editor" or debate sections as well as in conference sessions or in tenure committee meetings.

An additional relevant distinction can be made with regard to whether the communication is in written or oral form. Written communication is different in style and is, so far, better suited for storage and retrieval. For a long time, written communication was a single medium communication. This is changing with the advent of multimedia enhancement of texts. By contrast, oral communication was often (however, not always) already "multimedia" in the sense that the presenter of a paper at a conference could use overhead slides or audio examples to support an argument.

A final property of scholarly communication is how many people are both on the receiving and the originating (sending) end. We may differentiate between one-to-one, one-to-many and many-to-many communication media. Furthermore, few-to-few communication takes place in smaller groups (like seminars or workshops). There are examples for all types in academia. A bilateral exchange of messages between co-authors of an article falls within the first group and the presentation of a paper in a conference is an example of the second. The discussion in an E-mail list is of the third type and the collaborative web page of a research group of the fourth type. The following table summarises these properties of scholarly communication:

PROPERTIES of academic communication
- Synchronous/asynchronous
- Local/distant
- Slow/fast
- Informal/formal
- Written/oral
- Multi-medial/single medium
- One-to-one/one-to-many/many-to-many/few-to-few

Overview 1-4: Properties of academic communication

(d) *Communication functions:* Finally, it is helpful to distinguish four functions of scholarly communication. It can be either input or output oriented, it can be oriented towards the process or production of scientific knowledge or status-oriented.

Input oriented communication seeks either stimulation for thoughts, serves as creative "brainstorming", or serves to gather information which also includes the reading of publications – "deferred" communicative acts of other researchers. Receiving feedback on one's own publication by colleagues also falls within this first category.

Output oriented communication is mainly the notification and circulation of information or knowledge through publications and academic talks, but also through teaching, giving interviews to the media, and public lectures. The most important output-oriented communication is publishing. Its functions may be further differentiated (cf. below 1.2.2.1).

Apart from what I have called "communication with the research object" above, *process or production oriented* communication is mainly related to working relationships, i.e. with project collaborators, co-authors, participants in workshops etc. It aims at generating new knowledge through brainstorming, discourse and collaborative analysis as well as at discursive testing of arguments and conclusions, including evaluation of research.

The last function is not directly related to the content of research, but nevertheless very important in the daily routine of every researcher. *Status-oriented* communication includes simple socialising, communicative acts with a view to enhance one's reputation, as well as all sorts of administrative communication. See the following synopsis for the various functions of scholarly communication:

FUNCTIONS of academic communication

INPUT-oriented

- Stimulation – brainstorming
- Information gathering, incl. reading of publications
- Receiving feedback on publications

PROCESS- or PRODUCTION-oriented

- Discursive testing of arguments (evaluation)
- Generating new knowledge (brainstorming, discourse, collaborative analysis)

OUTPUT-oriented

- Notification and circulation of information (publications, talks, teaching, media and the public)

STATUS-oriented

- Socialising, enhancing reputation
- Administrative communication

Overview 1-5: Four types of functions of academic communication

1.2.2.1 Functions of the publication system

The nucleus of formal communication among academics is the publication system. Kling/ Covi (1995) suggest that scholarly publishing should be viewed "as one part of the scholarly communications systems that connect authors and readers." Academic publishing fulfils a number of functions. Various scholars have thought about these functions. Kircz/ Roosendaal (1996), for instance, distinguish different stages in the research process, "from conceptionalisation of problems, to theory, to hypotheses, to predictions and testing, and finally interpretation of research outcomes". From this they deduce a number of communication needs resulting from research needs in these stages: from awareness of knowledge, of new research outcomes and of specific information to scientific standards, to a platform for communication and finally to ownership protection. Finally, they come up with four main functions of academic communication (ibid., 4): certification, registration, awareness, archival functions. By contrast, Guedon (1994; similarly Burg 1999, 123) distinguishes three main functions of printed publications in academia: communication and diffusion; legitimisation and authority; and archiving and memory. Morton (1997, 6) lists the following central values of scholarly communication: serial communication, the preservation of data, public disclosure and feedback from informed readers to authors or editors. Finally, Franks distinguishes, apart from distribution of scholarly text, the following three important functions that a journal can provide (Franks 1993, part I): certification, archiving and marketing. The following Table 1-2 compares these four voices from the literature:

Table 1-2: Functions of the scholarly publication system

Kircz et al. 1996	Guedon 1994	Morton 1997	Franks 1993	*Synopsis*
Certification	Legitimisation & authority		Certification	*Certification*
Registration, i.e. ownership protection				*Registration*
Awareness	Communication & diffusion	Serial communication	Distribution	*Diffusion*
Platform for communication		Public disclosure	Marketing	*Transparency*
		Feedback from informed readers to authors or editors		*Discourse*
Archiving	Archiving & memory	Preservation of data	Archiving	*Preservation*

As a synopsis, I find that Guedon's three categories are most useful but that they should be extended on the basis of proposals by other authors. I then arrive at six functions, namely:

1. *Certification*, that is the "quality stamp" given by the community;
2. *Registration*, which records a research result and relates it to particular authors (including the "time stamp" for priority claims);
3. *Diffusion*, that is the distribution (communication) of academic knowledge including awareness building;
4. *Transparency*, i.e. the disclosure of results with a view to both legitimise the research, to allow for connecting research and to open it for control and re-assessment;
5. *Discourse*, as a publication is one element of a wider on-going communication process in the research communities; and finally
6. *Preservation*, i.e. archiving and building up the memory of academia.

I shall employ this schema in section 7.5 when assessing the incremental change from P- to E-publishing in academia.

1.2.3 The diffusion of ICT in the scholarly communication system

> "Technologies may not be sufficient to bring about major changes in scholarly communication forms. Efforts need to be made to identify what factors promote or inhibit using the Internet in scholarly communication so that we can have a strategic plan for such a transition."
> (Zhang 1998, 249)

Having defined what I mean by ICT (1.2.1.1) and having explored the various dimensions of the scholarly communication system (SCS, 1.2.2), the next step in the elaboration of my model is to look at the changing SCS (cf. the rounded corners box in Figure 1-3).

I have already noted above (cf. Table 1-1) that the SCS is changing from the "traditional", pre-ICT situation towards a state in which ICT play a significant role. I chose to label this future state "cyberscience". In-between, that is today, academia is in a transitory status quo. Obviously, the diffusion of these new media technologies and numerous value-added services is well under way. This is by no means a linear process and it differs from field to field. Although the elements of the academic Internet may be considered to be a technology cluster (Rogers 1995, 15) as its elements are closely interrelated and often come as a package, the adoption rates of the elements is not the same for all. For instance, E-mail and access to the WWW are already practically universal, while groupware or video-conferencing are only at the beginning of their potential S-shaped diffusion curves of adoption. I call "*cyberness*" *the level of ICT use* of an academic field, speciality or discipline, in other words the relative position on a (hypothetical) combined diffusion curve of the various forms of ICT use (E-mail, databases, E-lists, groupware etc.).[57]

The intermingled diffusion processes do not take place in a vacuum. While, at the end of the day, it is the individual actor, the scholar, who adopts or refuses to adopt a new technology, the environment heavily influences his/her innovation decision. In some respects, the decisions are not taken at the individual, but at an organisational level – for instance by a university, a scholarly association or a single research institute. Furthermore, the organisational and individual levels influence each other, as it is individuals who shape decisions at the former level, too. Complex diffusion networks with opinion leaders, innovative entrepreneurs, external change agents and a mass of adopters of varying innovativeness shape the process.

The core assumption of the analytical framework of actor-centred institutionalism, a prominent and widely used sociological and political science approach, is

> "that social phenomena are to be explained as the outcome of interactions among intentional actors – individual, collective, or corporate actors, that is – but that these interactions are structured, and the outcomes shaped, by the characteristics of the institutional settings within which they occur" (Scharpf 1997, 1).

This approach places its main focus on institution-based information, as they in many cases "will be sufficient to derive satisfactory explanations, and it makes pragmatic sense to reduce levels of abstraction only gradually in the search for theoretical explanations" (ibid., 42). Following this line of reasoning, the academic culture, the legal environment, and economic constraints shall be considered in-depth (beyond the activities of individuals) since they shape what are perceived as feasible options by the actors.

[57] I shall operationalise "cyberness" in section 3.3.11.

In sum, a number of institutional, functional, technical and actor-related factors play a role in our research puzzle.[58] These factors will not only help us to understand the status quo, but will also contribute to future development. Note that limitations and problems perceived during diffusion not only impact on the move from traditional scholarship to cyberscience, but also on the development of the technologies. Along the diffusion path, ICT tools are gradually adapted to the needs of academia. This is the last element of my core model (the "change model") summarised in the following Figure 1-4:

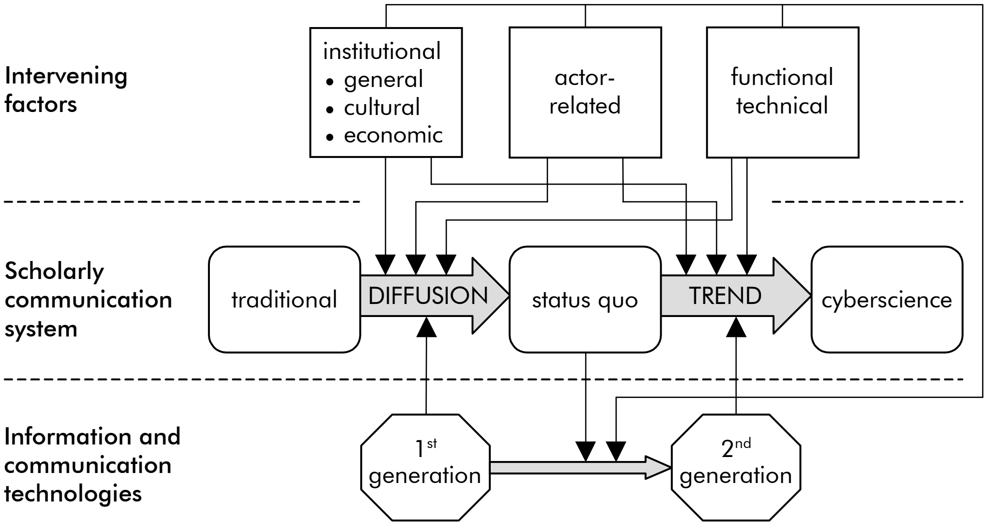

Figure 1-4: Modelling ICT-induced change of the scholarly communication system ("change model")

These three groups of intervening factors that influence the changes under way in the SCS are presented in the following sub-sections and will be discussed in more detail in the following chapters. For all three groups, we shall be able to find some factors that are important for an explanation of the status quo and of trends in academia as a whole, and a more specific subgroup of factors that are relevant for explaining the differences of ICT use between the academic (sub-)disciplines.[59]

1.2.3.1 Institutional factors

Both diffusion research and STS studies have pointed out that institutions in a broad sense play an important role when it comes to explaining why technologies diffuse and why they are shaped in a certain way. For my purposes here, it seems useful to distinguish between three types of factors at the institutional level: (1) general co-ordinates, (2) economic factors, and (3) cultural parameters.

(1) *General co-ordinates*: This group includes a number of factors setting crucial framework conditions on the level of law, politics and disciplinary environment. The *legal* en-

[58] Focussing on the use of electronic information, Mlynek (2001, 48) distinguishes technical, organisational and personal factors.

[59] The latter subset will guide my analysis of the disciplinary differences in chapter 3.

vironment plays an important role. In particular, the uncertainties of how problems related to copyright issues in the digital environment will be solved contributes to the set of intervening factors.[60] Furthermore, how *politics* engage in science and research, i.e. the policy environment, influences, for instance, whether international co-operative networks and projects are favoured.[61]

At the level of (sub-)*disciplines*, the overall number of active researchers in a speciality and their distribution around the globe could be of importance. One hypothesis is that the smaller and more specialised a community of researchers is, the more likely it will be dispersed, the more important it could be to have the opportunity to keep in contact and to collaborate via ICT. Furthermore, formal communication via publications may be affected by size because the number of potential readers directly affects pricing and hence the likelihood to shift online.[62]

(2) *Economic factors*: ICT hardware and software, including appropriate access to the networks and fees for databases etc., require a considerable budget. Therefore, we should expect economics to play a role. In particular, the overall budgetary situation of academic libraries and research units (institutes, universities and associations) will have an impact. Furthermore, the cost of publishing influences the attractiveness of this alternative route.[63]

At the disciplinary level, one may hypothesise that the more applied the research in a sub-discipline is, i.e. the more likely commercial application is, the smaller the openness towards a system of free (E-)pre-print publication or, more generally, towards sharing information. This should relate to the ownership of the information: these researchers have good reasons not to share research methods, materials, and results, as the work can be lucrative and is often highly competitive (similarly Kling/McKim 2000, 5). Furthermore, this variable impacts on the average budgetary situation of a speciality and, hence, on the availability of state-of-the-art technology.[64] This connects to a final dimension: the overall budgetary situation of a field and hence the ability to provide the E-infrastructure might play a role.[65]

(3) *Cultural parameters*: Obviously, cultural aspects will impact on the changeover from the traditional ways of doing research to potential new modes. For instance, the general prestige of paper in academia influences the path to E-publishing.[66] Given the dominance of the English language for international exchange in many fields, whether or not English is the first or a widely spoken second language in a country might impact on usage patterns. In addition, general attitudes vis-à-vis science and the resulting culture of doing science and research in a country should not be overlooked.

At the disciplinary level, what many general "science" studies have shown might also play an important role in our context here: the differences in the professional cultures among disciplines (e.g. Becher 1989). This can be treated at the level of encompassing

[60] Cf. 9.2.
[61] Cf. 9.1 and 11.1.
[62] Cf. 3.4.1.
[63] Cf. 9.1, in particular in 9.1.1 and 9.1.3.2.
[64] Kling/McKim (2000, 5) also list "research project costs" among their important structural characteristics impacting on the perception of formal, peer-reviewed publishing. In particular, high cost research projects usually involve large teams who subject their research to strong internal reviews before publishing.
[65] Cf. 3.4.3.
[66] Cf. 7.3.2.3.

"science families", but also more specifically. For instance, whether a discipline is rather competitive or rather collaborative might influence both publishing (e.g. pre-print culture) and collaboration practices (open or closed). Interconnectedness, that is the degree to which the researchers in a field are linked by interpersonal networks is positively related to innovativeness (Rogers 1995, 381). The mutual visibility of ongoing work in the field (transparency) is also related to interconnectedness and may also be positively related to a favourable attitude towards sharing reports and data (Kling/McKim 2000, 5). Furthermore, whether a uniform method or style is part of the common understanding in a discipline, and whether all are acclimated to the same kind of discourse might impact on the likely system of publication and quality control. Some fields are deeply split when it comes to their research paradigms (unified vs. competing paradigms). The publishing tradition in a field may be a factor, too. Whether books play a prominent role, or not, may impact on the likelihood of "going online". Also the degree of concentration of journals may play a role (Kling/McKim 2000, 5). Finally, the cumulative production culture of a discipline probably is one of the main variables. By this I mean more than a collaborative culture (see above), but whether a discipline engages in some sort of a collective building of data- or knowledge bases, i.e. whether the researchers work on different "construction sites" of an identical "meta-site", hence producing additive or cumulative knowledge. The alternative is separated, not, or only vaguely, connected sites.[67]

The following Overview 1-6 summarises the institutional variables:

INSTITUTIONAL FACTORS
influencing scholarly communication patterns

	Academia as a whole	Disciplinary level
(1) General co-ordinates	• Legal environment • Research policy environment	• Size • Distribution around the globe
(2) Economic factors	• Funding (libraries, institutes) • Cost issues of publishing	• Closeness to economic application • Competitiveness • Funding
(3) Cultural parameters	• Prestige of paper • Language • Science culture	• Science family • Publishing traditions • Uniform method/style/paradigms • Cumulative production • Culture of collaboration

Overview 1-6: Institutional factors

[67] Cf. 3.4.4.

1.2.3.2 Technical and functional factors

A major outcome of diffusion research is that innovations will be adopted more rapidly than other innovations in case individuals perceive them as having greater relative advantage over the earlier technology. In addition, higher "compatibility", that is consistency with both the existing values (see above) and the needs of potential adopters, positively influences adoption behaviour (Rogers 1995, 16). In other words, the innovation has to offer a positive cost-benefit balance. We may distinguish between (1) purely technical and (2) functional aspects of this account of compatibility and advantage. It seems equally possible to discuss the technical properties, not as intervening factors, but rather as part of the independent variable "ICT" (that is in 1.2.1.1), because they determine the supply side. Here, I have chosen to discuss them separately with a view to stress their importance in the diffusion process.

(1) *Technical properties* of ICT have always mattered and will play an important role in the future to see whether or not researchers will use ICT and whether the new media will be apt to fulfil their communicative needs. On a first level, I observe that the new technologies have specific properties distinguishing them from the traditional communication media (e.g. the phone), like asynchronity or speed or multimedia (below 1.2.4.1(3)). In principle, these properties enable the researcher to establish new forms of communicative links. Whether or not they will actually do so depends, first of all, on the *attractiveness of the innovative features* – the "perceived usefulness" (Kirkup/Jones 2000). It has been observed, for instance, that the Internet only appealed to the masses (also among scientists) when the rather clumsy text- and list-based older interfaces like Gopher were replaced with the World Wide Web technology that allows for easy graphical browsing. Other examples are digital libraries, which have new features (such as full text search): "As we build new digital libraries we add functionality – capabilities that have never been present in traditional libraries." (Harter 1996b, 1) Similarly, a newsgroup "offers opportunities for information and data sharing" (Lewenstein 1995, 125). This is technically not possible without the electronic media. In more general terms we may say that the user interface is very important. This is not to say that researchers would not accept a less convenient technology for a while if the other advantages were still considered very important. In the long run, however, we may hypothesise that only "ripe"[68] technologies are able to convince the critical number of participants. User friendliness of the software is one important element as regards the potential for widespread use.[69]

Obviously, one of the more important issues hindering or favouring the widespread use of some of the new ICT is *screen technology*. ICT is based on digital technologies requiring its users to read on and look at screens all the time. For sure, researchers often reduce the on-screen time as much as possible, for instance through printing the content displayed on-screen. In many cases this strategy seems well suited, e.g. for reading standard linear texts, say conventional scientific papers offered for download on the WWW. However, many of the possible advantages cannot be enjoyed off-screen.[70] Think of a video clip recording an experiment, a dynamic database or a videoconference. Here, screen

[68] In this context, "ripe" means simply that the technology has moved beyond the early stages of development. For instance, software is released with decimal numbers and all numbers below 1.0 are considered pre-releases. However, often software needs longer to run stable or to provide the user with an easy-to-use interface.

[69] Cf. e.g. with regard to authoring tools 6.5.1.

[70] Cf. 6.4.3.

technology is paramount and already, there seem to be a number of promising new technologies making digital screens as good a display technology as paper.[71] Closely related to the quality of screens is portability of the display and communication devices, i.e. independence from constant power supply for long periods, as well as physical robustness. All this has to do with working habits of academics, which require ripe technological solutions before they can replace the traditional ways.[72]

Anyone who has participated in an online Internet videoconference will probably acknowledge the promising potential of this new technology. However, restrictions of the bandwidth of the network make it still a mixed experience. Sufficient *bandwidth* is also important for convenient (real-time) database access and online collaboration when synchronicity is key, in particular given the constantly rising number of network users inside and outside academia.

A further important technical factor influencing whether or not ICT will actually impact on how academic communication is performed, is the *reliability* of the hardware and software. As long as trust in the technology is severely hampered due to frequent personal experiences with computer crashes, network failures, and data loss, it is rather likely that the relatively secure conventional communication channels, in particular publishing on paper as opposed to online-only electronic publishing, will remain the first choice.[73]

Also *archiving* of scholarly communication – although not solely a technical, but also an organisational problem – needs to be addressed in a convincing and sufficient manner before scholars will be inclined to entrust their research communication to the digital world.

A final technological influence is exerted by a lack of *standards* for the various formats. Although the Internet is based on one such common standard, HTML, there are many proprietary formats, which endanger interoperability.[74]

(2) From a *functional perspective*, first, faster media may be more welcome in those disciplines with higher time constraints. In other fields, a relatively slow pace of discovery may limit benefits. For instance, the "half-time" of knowledge is quite different and hence may impact on whether fast and up-to-date information (as promised by E-publishing) is important. Disciplines also vary as to their visual or non-visual orientation. In those fields where multimedia communication offers substantial improvements, the likelihood of their implementation should be higher. The same applies to intense dependency on data where the computer has always played a substantial role and the networked computer may offer promising opportunities. Furthermore, the importance of being "embedded" in a physical locale (e.g. a laboratory) could impact on the intensity of ICT use. Finally, whether or not a field is internationally oriented may influence the media of communication.[75] Although the discipline or speciality determines much of what is actually done in research, we also have to include in my analysis functional aspects relating to task-specific differences within a given discipline (we may even expect cross-disciplinary similarities). For instance, the need to co-operate is not always equally strong for any given part of a project and hence the need to communicate at distance may vary.

71 Cf. 2.3.1.
72 Cf. e.g. 7.3.2.1.
73 Cf. 7.3.2.1.
74 The technological factors influencing scholarly communication patterns will be discussed in more detail throughout chapter 2 and in various places of part three (e.g. in 6.5.1 and 7.3.2.1).
75 Cf. 3.4.2.

Also, the time pressure for typical tasks may be more or less high. Accordingly, specific properties of communication such as speed and synchronicity may be of varying importance. Furthermore, what type of output (form of publication) has to be generated obviously impacts on the use of digital media. Last but not least, whether the research subject requires a single- or multi- or even inter-disciplinary approach may play a role.

TECHNICAL & FUNCTIONAL FACTORS
influencing academic communicative patterns

General (technical) level

- Attractiveness of innovative features/user interface – user friendliness
- Screen technology, portability (independence from power supply)
- Bandwidth of network
- Reliability of hardware and software
- Solution of archiving problems
- Lack of standards

Disciplinary level

- "Embeddedness" in physical locales
- Visual orientation
- Dependency on data
- Pace of discovery and time pressure
- Geographic focus of subject

Task level

- Need to co-operate at distance
- Time pressure
- Type of output to be produced
- Single- versus multi-disciplinary work

Overview 1-7: Technical and functional factors

1.2.3.3 Actor-related factors

Actors play a crucial role in the diffusion of technologies. On the one hand, individual and collective actors are the basic units adopting innovations. We can distinguish between (a) aspects important for individual behaviour and (b) factors playing a role at the organisational level. On the other hand, the history of innovation has highlighted the importance of agency for the process of diffusion (c).

(a) There can be no doubt that variables at the *individual* level account for different communicative behaviour. First, a researcher's reputation, status, career stage as well as age influence how likely particular forms of communication are and with whom one communicates. Another major factor influencing the individual's communicative preferences is the familiarity with and – related to this – one's general attitude towards technology in general and ICT in particular. There are "passive" people who only use what is available and what they are forced to, and there are "activist" researchers who actively explore the new opportunities. Furthermore, experiences with past co-operation will impact on whether an individual is likely to engage in new collaborative endeavours, in case they are not absolutely essential for the type of work s/he is carrying out. Related to the first point, i.e. status, is what we may call "individual peripherality". Access to informal networks and to physical meeting places is not equally distributed and available to everyone. Both will impact on whether technologies enabling exchange and meeting over distance are attractive.

For sure, these individual factors account for variation in usage and, on an aggregated level, for a particular communicative culture. However, it seems likely that if the overall trend is different from what individuals (or groups) prefer, the individuals will have to adapt in the long run. Take the example of submitting manuscripts to a journal: while a traditional paper journal may still accept submissions in paper, E-journals mostly do not. If a researcher wants to publish in such a journal, s/he has to adapt and send an electronic paper.[76] Hence, there is both an imitation and a pull effect as the example of others influences individual behaviour. After surpassing a certain minimum threshold of people using a specific application of quoting a particular E-journal or contributing to a common knowledge base, the incentive for latecomers to join increases. Critical mass is often necessary (Grudin 1994).

(b) Other factors play at the *organisational* level (research institutes, universities and scholarly associations). I have already mentioned funding (above 1.2.3.1) as an important factor. In many cases this will correlate with whether the research institute is to be considered "core" or "periphery" within the discipline, i.e. with its reputation. But there is more to reputation than financial resources and hence infrastructure. It also influences directly the communication needs: the more at the centre of a speciality an institute is, the less need there is to actively engage in establishing communication since the others will seek contact. This may not only play at the level of the individual research institute, but the academic peripherality or centrality of the country will influence how important it is to establish communicative links. Likewise, the socio-economic development status of the country in question will influence the overall stance of the research community. Furthermore, the size, i.e. the number of researchers at a given institution, influences the need for external communication and hence ICT. The smaller the institute, the more a researcher will seek feedback and information from outside. However, if there is a critical number of researchers at one spot, a new demand for technology-supported internal communication may arise (note that the WWW was developed at CERN, a very large institution, exactly for this purpose). This hypothesis is matched with a generalisable result of diffusion research, namely that, for the most part, larger organisations are more innovative in the sense that diffusion may proceed quicker[77] (Rogers 1995, 379). Next, something we might call "internal culture" may influence how an institution communicates. By culture I mean for instance the habit of frequent face-to-face meetings in the form of a jour fixe or regular internal seminars or a meeting place like a cafeteria, as opposed to a more solitary working style with closed office doors.[78] In more general terms, the degree to which the researchers are linked by interpersonal networks ("network interconnectedness", Rogers 1995, 381) is favourable to the degree of innovativeness of an organisation. Institutional persistence is a final factor to be listed here. If the move to a new technology involves a large step,[79] it is likely that we shall see institutions (individual research units, universities, scholarly associations) to retard the development.

(c) *Agency* (in the narrow sense): The role of innovators (active information seekers who are inclined to adopt earlier), opinion leaders (who are able to influence other individuals) or even innovation champions (charismatic individuals who throw their weight be-

[76] Some of the aspects touched upon here are discussed in the chapter on skills and roles (chapter 5, in particular 5.1).

[77] This has to be distinguished from the perhaps generalisable insight of technology policy research that rather smaller units are able to come up with innovative ideas and products.

[78] These aspects will be dealt with in the chapter on the spatial consequences of cyberscience (chapter 4, in particular 4.2.4).

[79] E.g. in the area of knowledge representation, cf. 6.5.2.

hind the innovation, thus overcoming indifference or resistance)[80] play an important role in any diffusion process. In our context, those individuals which dare to use innovative E-journals or new communication channels first (trailblazers) and the presence and activities of entrepreneur-minded researchers in a field is crucial. Many of the outstanding developments, like the WWW itself or the first E-pre-print archives, would not have been such or so early a success if there had not been a few driving individuals. Gresham (1994, 48, quoting Sproull/Kiesler 1991) calls this "electronic altruism". In turn, the reputation of the authoring or editing institution promoting an E-journal may be related to the success of such an initiative.[81]

ACTOR-RELATED FACTORS
influencing academic communicative patterns

Individual aspects:

- Reputation, status, career, age
- Familiarity with and general attitude towards technology (passive vs. activist)
- Experiences with co-operation
- Individual peripherality (access to informal networks,
  access to physical meeting places)
- Imitation and pull effect

Organisational aspects:

- Funding
- Peripherality (reputation)
- Size
- Internal "culture"
- Institutional persistence

Agency:

- Existence of cyber-entrepreneurs
- Reputation of editing institution

Overview 1-8: Actor-related factors

1.2.3.4 The intervening factors at work

The various intervening factors outlined above play at different levels and contribute differently to an overall explanation of ICT use in academia. Furthermore, we face the usual social science problem, that is the sheer number of intervening variables, and the impossibility of doing experiments in which we would be able to hold constant all but one variable. It is the purpose of this subsection to complete my "change model" by elucidating the relationship between the various factors and, hence, to put the subsequent analysis into perspective.

Some factors relate to academia as a whole; others play at the disciplinary level; and a third group helps us to understand individual innovation decisions (either of individual researchers or organisations). The general technical factors and half of the institutional factors belong to the first group. We find factors playing at the disciplinary level both in the institutional, functional and actor-related groups of factors, whereas most actor-related factors and the functional aspects related to the task level are of the third category. Let me look at these groups, in turn.

In this study, as with sociological research in general, I am *not interested in the explanation of individual cases*. Innovation decisions taken by individual researchers and or-

[80] Cf. Rogers (1995, 398).
[81] The role of individual activists is the main theme of 3.4.5.

ganisations (research units, associations etc.) are only relevant for my model at an aggregated level. Differences at the individual level either cross each other out or are visible at the next level, that is at the level of disciplines or countries. If a large majority of individual researchers in a field show the same preference, this would suggest that this is not only an individual characteristic, but also one at the next analytical level. For instance, the existence of cyber-entrepreneurs and the reputation of the editing institution of a new E-journal (agency) become relevant at the disciplinary level. Another example is peripherality and "digital divide". There is a strong case that whether a research institute (or country) belongs to the core of its discipline or not, is an important variable for the usefulness and hence the level of ICT use.[82] A similar argument holds for task-related differences (functional aspects). In this study of cyberscience as a cross-scientific phenomenon, I am looking at entire sub-disciplines or specialities. In general, a field is characterised by a variety of tasks and again, if one task is becoming so prominent that it can serve to describe the whole field, then it will be accounted at the disciplinary level.[83]

By contrast, those various *factors playing at the disciplinary level are central* to the comparative chapter of this study (chapter 3). In the interviews, I gathered evidence for all those outlined above. I will confront them with the variation among the various academic fields in section 3.4. The resulting picture is one of multiple causation. No single factor is able to explain all cases. Furthermore, the various factors interact and are often interdependent. In sum, there are neither necessary nor sufficient causes for "cyberness"[84] of a field.[85] It seems plausible to assume that a configurable technology such as the WWW can be adopted and used by different fields in different ways (Kling/McKim 2000, 3). Not only that the new media are actually used, but also how they are used and shaped is specific to the needs of the communities. We are therefore likely to see continuous differences among the various fields instead of convergence.

Equally important are those *factors relevant for academia as a whole* as they will inform my analysis in Part Three of this study. As regards the economic factors and the legal environment, they are dealt with in their own chapter (9), but I shall make reference to them also in the chapter on E-publishing (7) and on roles in academia (5). The general cultural parameters will contribute to a deeper understanding at various places of this study. For instance, the cultural factor "prestige of paper" plays a key role in the transition from paper to digital publishing.[86]

The *technical variables represent a special case* in my model. On the one hand, they influence innovation decisions and hence connect the individual with the general level. On the other hand, they are highly dynamic. One may argue that they will become less and less important as time goes by. User interfaces are being improved on the basis of the feedback of first user experiences. The continuous development of new applications (inside and outside academia) presents a big incentive for early-adopters to try them out,

[82] I shall discuss this at several occasions on the basis of general considerations and the existing literature (e.g. 4.3.4.3).

[83] This plays a role for instance when I discuss the differences within the specialities in the subdiscipline "European studies" (part of political science, see 3.2.2.1). There are those who apply quantitative methods and hence use databases more frequently than those which are more qualitatively oriented.

[84] For the notion of "cyberness" see above in the text near fn. 57.

[85] I shall further discuss disciplinary factors when assessing the future of both knowledge representation (cf. 6.5) and print publishing, in particular as regards the publishing traditions and individual agency (cf. 7.3.2).

[86] Cf. 7.3.2.3.

to give feedback to the developers and thus accelerate the development. Innovative applications seem to be mainly developed by a small group of people, reinforcing each other in a feedback loop. Network bandwidth is still too small for the more sophisticated multimedia real-time application, but given the worldwide efforts to realise high-speed networks, this seems only a matter of time, too.[87] Therefore, the technical factors contribute to our understanding of the dynamics of the move from first to second generation ICT and from traditional to cyberscience.[88] With regard to differences among disciplines, they are largely the same for everyone in every field everywhere. For instance, archiving is not discipline-specific and will probably be resolved on a meta-level within academia.[89] The reliability of computers, their dependency on power supply and the quality of screens is completely independent from academia (except applied IT research, of course). Network bandwidth varies a lot, but this is to be dealt with under the heading institutional or geographic factors (budget), since the variation is not a technical problem. However, I will address one specific group of technical issues separately, namely those whose consequences are different for each field.[90]

To sum up, on the one hand, it was necessary and fruitful on a conceptual level to distinguish between all factors possibly influencing how ICT impacts on all aspects and instances of scholarly communication. On the other hand, the above discussion reveals that, for the purpose of generating generalisable insights about the overall impact on research, it is not useful to consider in more depth each and every one of these intervening factors. Not all of them can or do, for logical and empirical reasons, contribute to an explanation on an overall level (which is, however, the aim of this study). Some of them may play a role mainly in explaining individual cases. Others may, in aggregated form, be part of the main group of factors, namely those which distinguish the various sub-disciplines (and will hence be discussed together with them). Still others cannot be considered here in more depth because of the necessarily limited scope of this study, but are addressed in the appropriate sections where useful. While being important in the long run, a last group of factors (e.g. screen technology) is considered to be of diminishing importance as this study looks a few years into the future when these technological problems will most likely be solved. Where appropriate, the latter will, however, be specifically addressed.

1.2.3.5 Qualitative trend extrapolation

The final element in my analytical "change model" is the extrapolation of the developments with a view to drawing a differentiated and realistic picture of how ICT is changing the scholarly communication system in the near future. Note that this involves two interrelated foresight enterprises, namely of the technology (ICT) and, to some degree, the social system (academia), which are done simultaneously (Porter et al. 1980, 146).

There is not enough relevant information available for quantitative mathematical-statistical calculations, that is for trend extrapolation in the narrow sense (ibid., 115 ff.). The general statistical material published by organisations such as OECD, Eurostat or

87 Cf. 2.1.2.
88 In particular, I shall discuss the short-term impact of various technical factors with regard to the future of knowledge representation (cf. 6.5.1) and the prospects of E-publishing (7.3.2.1).
89 Cf. 7.3.3.
90 Among them is, for instance, the rendering problem – the problem of making special symbols available in digital form (cf. 3.4.2.2).

EITO does not focus on ICT use in academia.[91] Theoretically, it would be possible to gather data on computer use in academia in many dimensions (for instance, figures on E-journal use, E-mail use as opposed to traditional writing or telephoning, knowledge of groupware application, number of academic databases etc.). However, apart from the enormous practical problems of this endeavour, it would be nearly impossible to get reliable data on the past, with a view to calculating any trends. This is because, as there was and is no system of automatic recording of ICT use, I would need to rely on ex post estimations of interviewed researchers. While such information gathering may be useful in a qualitative sense with a view to overall trends, it would be highly dubious to base mathematical-statistical computations on such vague information. What is more, we cannot assume that any past trends would continue unchanged into the future. It is all but sure that curves would indeed be S-shaped (as observed by past diffusion research, see above), as discontinuance is an immanent possibility. Furthermore, we cannot say for sure what proportion of the whole population of researchers would ever adopt the new technologies (or which sub-set thereof) as we cannot know in advance whether the new technologies will replace or only complement older technologies.

In short, our trend extrapolation has to be a *qualitative assessment*, for both theoretical and practical reasons.

This trend analysis rests – similar to the first part of the model, which aimed at explaining the status quo – on the assumption that the intervening factors will play their role here, too. There is no reason to hypothesise that the factors as presented above (1.2.3.1 to 1.2.3.3) will not influence the future development as they have done in the past. For sure, a number of factors is evolving along the path to cyberscience. In particular, the technical factors are changing not only in their empirical state but also in importance as time goes by (see above 1.2.3.4). Also the legal environment is changing constantly, as is, to a certain degree, the science policy environment. Furthermore, even general co-ordinates (as the size of a field or its distribution around the globe) are not fixed. We shall have to take due account of this inherent dynamic. Most factors, however, are not likely to change in the period observed here, as we are intending to look only a few years into the future.

There is still another important reason not to extend the time horizon. Looking back at the technological development and the evolution of usage patterns in the most "advanced" sub-disciplines over the last decade, another decade from now should be enough with a view to let technology mature, budgets being attributed, legal decisions be taken and individual experiences grow. The fast speed of technological innovation, however, makes a longer-term assessment unreliable.

An important element of my qualitative approach are the results of my empirical inquiries, in particular of the *trend assessments of experts* (both my interviewees and in the literature[92]). The interviewees have been asked what cyberscience-related developments they expect in the near future.[93] Their opinions, however, have to be treated with care. While the large majority of them were indeed experts as regards the present use and

[91] The single exception is chapter 7 of the OECD report (1998), e.g. on E-mail use; these data are, however, highly aggregated or outdated.

[92] Including the results of the Delphi surveys by Berkowitz (2002) and Keller (2001a). A similar approach is taken by Walsh/Bayma (1996, 346): "When a variety of respondents from different fields all converge on a common response for how CMC might affect some aspect of scientific work, we take this as evidence that such a change is likely."

[93] Cf. in particular questions 46 to 50 as listed in Annex III.

impact of the technology in their respective fields, only very few had ever pondered deeply the future developments in advance of the interviews. Strictly speaking, there are (can be) no experts of the future. Despite these limitations, the assessments of those involved in the daily research business are, nevertheless, a good indication of possible future developments.

Furthermore, a *comparative approach* may be helpful in special cases. As already mentioned, some of the disciplinary variables are dynamic in the sense that they are not fixed but evolve over time. This puts us in the position to draw some cross-disciplinary conclusions related to the timing of developments. If we find the same set of features (values of variables) in two sub-disciplines, but different outcomes (i.e. levels of ICT use for scholarly communication), then we may infer that, most likely, the discipline with the lower level of CMC was just late to experience ICT and may "catch up" soon. Diffusion of technologies is never simultaneous but starts where inventions are made, and its spreading over time is contingent upon historic and other circumstances (as discussed in diffusion research). Only if this condition is met, i.e. if the two cases show the same variable configuration, would this inference be allowed – with much prudence, though, since there is always the possibility that we have overlooked any case-specific conditions. In any case, these inferences will be backed by assessments of experts in the respective field.

Past research in the diffusion of technologies has shown that "*interactive technologies*"[94] are a special case. First, the benefits of an interactive innovation flow both backward in time to all previous adopters and forward in time to all future adopters (Rogers 1995, 315).[95] Second, above a critical number of adopters, the "further rate of diffusion becomes self-sustaining" (ibid., 319). Communication technologies, such as the Internet, are model interactive innovations. In addition, the diffusion of communication technologies is reflexive (and hence self-reinforcing) as the innovation is using itself as a communication channel. E-mail and the WWW, now almost universal, are the most important channels for diffusing knowledge about new ways of doing in the WWW. Furthermore, additional conditions for successful diffusion processes (ibid., 379 ff.) are met in academia: network interconnectedness is high in academia; there are relatively many uncommitted resources available ("organisational slack"); the system is relatively open as researchers are linked not only internally, but also to individuals external of academia (and may hence receive additional input and incentives to explore and implement new technologies); in academia, rather informal structures prevail, it is rather not bureaucratic, and highly decentralised. Finally, it is known that innovations may be changed or modified by users in the process of adoption and implementation ("re-invention"). This enhances the so-called "trialability"[96] and may also contribute to more compatibility of the innovation. Re-invention obviously occurs frequently along the path to cyberscience, for instance as re-

[94] *Interactivity* is defined as the "degree to which participants in a communication process can exchange roles in, and have control over, their mutual discourse" (Rogers 1995, 314), whereby *mutual discourse* is the "degree to which a given communication act is based on a prior series of communication acts", *exchange of roles* means "the empathic ability of individual A to take the position of individual B (and thus to perform B's communication acts), and vice-versa", and *having control* is defined as "the extent to which an individual can choose the timing, content, and sequence of a communication act, search out alternative choices, enter the content into storage for other users, and perhaps create new communication capabilities".

[95] This is different as compared to non-interactive innovations where no other (neither previous nor later) adopters benefit from the adoption of any other adopter.

[96] The degree to which the innovation may be experimented with on a limited basis.

gards the management of E-journals (tools and procedures), link collection databases (software, portals), layout and content of academic intranets, E-archives etc. In sum, starting from these general observations based on diffusion research, we may expect that the diffusion of interactive Internet-based tools will continue and may reach a self-sustaining level.

To underline the obvious, the intended trend extrapolation not only has to be done in a qualitative way, that is by evaluating qualitative information and expert assessments, but also very carefully. That many variables play a role is not only a problem for the attempt to explain the status quo (see above), but even more so as regards future developments. As Geser (1996) rightly notes, "adequate predictions about the future impact of computer technology are only possible in spheres where reliable and stable co-determining conditions (on the individual, social or cultural level) can be identified". This condition is probably not met in the field of intellectual activities where "individual idiosyncrasies and informal interactional relationships are so prominent" (ibid.). I agree with Geser that the impact of computers on intellectual work is difficult to adequately assess by means of empirical research because they tend to mirror the current and past stages of applications. In other words, diffusion research is most fruitful when it comes to the analysis of past events. I therefore follow his advice to take

> "a more 'constructivist' approach (...) to assess the objective functional potentialities of existing technological equipment – and to extrapolate future enlargements of such potentialities on the basis of ongoing technological progress [and] imagining various possible development patterns ('scenarios') for alternative future intellectual worlds." (Geser 1996, 14)

The qualitative trend extrapolation is done in two steps. First, in Part Three, I shall draw conclusions on the basis of the discussions within the respective chapters.[97] In a second step, I shall pull together these various partial "scenarios" into one combined "vision" with a view to give a tentative answer to the question, to what extent all this will really happen.[98]

1.2.4 Impact assessment

'Impacts' refer to "the products of the interaction between a technology and its social context" (Porter et al. 1980, 58). In our case, the societal context is the sub-system "academia". Impact assessment combines three tasks – although they cannot be executed as sequential steps but rather together and iteratively (ibid., 156).

The *first* element of the assessment is the systematic search for potential consequences (*impact identification*), which are "changes that occur to an individual or to a social system as a result of the adoption or rejection of an innovation" (Rogers 1995, 30). In the tradition of technology assessment, "systematic" means that *potentially all* areas in which consequences can be expected should be included in the study. This involves an interdisciplinary approach (cf. 0.1.3). One looks for direct consequences (immediate responses to an innovation) and indirect ones (which are the result of the direct consequences). The latter are "consequences of consequences" or second, third or even higher order impacts

97 See sections 4.4 on the spatial scenario, 5.7 for the new role distribution, 6.3 and 6.5.4 on the path to a new knowledge representation, 7.3.3 and 7.5 on the future of academic publishing, 8.5 on quality control and 9.1.3.5 on the economics of the future publication system.

98 Cf. 12.1.

(e.g. Coates 1971, 228). Higher order impacts can be distinguished according to "generations", i.e. according to their logical and temporal "distance" from the direct consequences. We shall see that in the case of cyberscience all types of consequences can be found. I focus on impact in two areas, namely, first, the general impact of ICT-induced changes of the scholarly communication system on academia and, second, the specific impact on research substance. What I call "changes of the SCS" are the direct consequences of ICT use, whereas what I shall discuss under the label "general impact on academia" are indirect consequences of ICT use (first generation) and the "impact on research substance" is of the second generation. From the point of view of those promoting a new technology, one can further distinguish between anticipated and unanticipated (or unintended) consequences. Even many of the innovation champions, activists and cyber-entrepreneurs pushing the development further towards cyberscience are hardly anticipating some of the effects of scholarly ICT use. For sure, to name a few examples, E-publishing has been marketed as one way to overcome the serials crisis[99]; hypertext is favoured by some for its potential to enhance transparency;[100] and some academic discussion lists have been set up with the explicit goal to democratise academia.[101] By contrast – and apart from the question whether these intended consequences actually take place – I shall discuss a number of consequences that are probably not anticipated nor intended by anyone promoting CMC application in academia. In particular, many of those effects that I shall analyse under the heading „substance of research" fall within this category. Two typical examples are the changing input side of research and the influence on the choice of the research topic.[102]

Given the complexity of societal and technological developments (cf. above 1.2.3.4), even the most intensive, encompassing and in-depth search for potential consequences will always lead to a necessarily partial answer, and leave us with some uncertainty. The *second* element is then *impact analysis*, that is, looking at the likelihood and magnitude of the impacts identified. This is the consolidation of the often times extensive lists of possible impacts. With the impacts identified and analysed, the next step is "to determine their interrelationships and significance relative to the societal goals and objectives, pertaining to the technology" (Porter et al. 1980, 60). This is the *third* element of impact assessment, namely the evaluation of these consequences (*impact evaluation*). This is not the place to join the hotly debated issue of whether such assessments can be neutral or whether they necessarily involve value judgements (e.g. Porter et al. 1980, 352 ff.). Although I acknowledge the importance of this debate, I chose a rather pragmatic stance in it. The large majority of this study focuses on what I have called above the first and second element, namely the search for and analysis of potential effects. Only occasionally shall I go beyond this towards evaluation, notably in the various concluding sections of all chapters. My assessments there will be based on a carefully balanced analysis of what I find in the literature and of what I heard in the interviews from other scholars. Furthermore, a probably hardly disputed yardstick for the assessment will be used when I compare future scenarios with what would be left behind: the functions of the respective systems and how various technologies and configurations may fulfil them. For instance, when I assess the incremental changes from P- to E-publishing

99 Cf. 9.1.3.2.
100 Cf. 10.4.4.
101 Cf. 5.6.
102 Cf. 10.2.2 and 10.2.3.

in academia[103] I shall compare the two systems on the basis of the functions of the scholarly publication system (as developed above in 1.2.2.1).

Finally a note on methodology: Beyond the claim to be as systematic and encompassing as possible (see above), there seems to (and perhaps can) be no universally applicable way to get hold of the consequences of a technology for the system in question.

> "Impact identification is largely a process involving the systematic application of imagination and intuition. (...) (T)here is no 'sure-fire' algorithm for impact identification." (Porter et al. 1980, 157)

One typical approach is to look for impact according to the "EPISTLE" principle – an acronym standing for environmental, psychological, institutional/political, social, technological, legal, and economic impact (ibid., 158). In this study, I look at environmental and psychological impacts only occasionally, but address the five other dimensions in-depth. Hence, the categories of change and impact presented in the following are therefore not directly derived from any theory. Rather they are constructed by drawing, on an abstract level, conclusions from my empirical research (above all the expert interviews, including the various hints found in the dispersed literature). In this sense, this part of the study is an example of the grounded theory approach (Glaser/Strauss 1967; Strauss/Corbin 1990). We do not claim, however, to come up with a "theory" in the narrow sense, i.e. an encompassing system of interrelated causal assumptions that could predict specific future developments.[104] Given the obvious impossibility of gathering data *of the future*, the purpose of my impact assessment is rather to set the terms for a critical debate about the phenomenon under consideration, including the grounding of recommendations for policies under conditions of uncertainty.

In this section, I shall, first, describe the kind of potential changes taking place in the SCS (1.2.4.1), followed by a discussion of the general impact of ICT on academia (1.2.4.2), and the substance-related impact (1.2.4.3). This follows the steps in my basic model as outlined in Figure 1-3 in above. The following Figure 1-5 highlights this part of my analytical model in more detail:

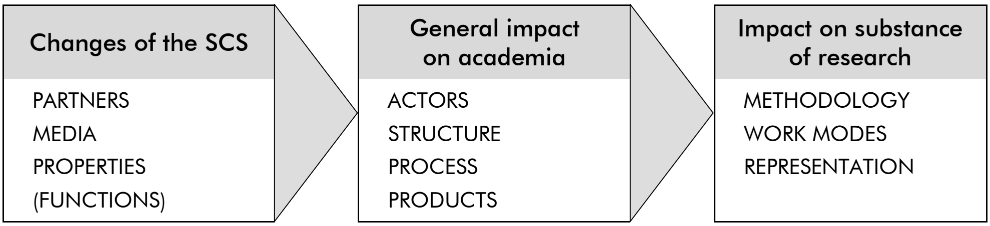

Figure 1-5: The chain of impact from SCS changes to research substance

1.2.4.1 Changes of the scholarly communication system

In 1.2.2, I distinguish various characteristics of scholarly communication in terms of communication partners (1), means (2), properties (3) and functions of communication (4). In all of these dimensions the difference ICT makes can be observed.

[103] Cf. 7.5.

[104] Rather, I stick to an analytical framework specifying and classifying relevant factors. This can potentially serve as a first step for developing a proper causal theory, in the future.

(1) Changing communication partners

Talking about the *first* layer of communication, i.e. with the object of research, a variety of new "partners" can be addressed via the new ICT. For instance, remote access to databases and instruments allows researchers to extend their field of action. Also, interview partners or survey subjects in remote places may come within reach without the necessity to travel. As libraries go online and become digital and virtual, access to remote bibliographic catalogues and eventually full text material adds to the local resources.[105]

At the *second* layer, i.e. with other researchers and research-related staff, it seems that the new ICT fully exploit what the phone and fax technologies have begun, namely the potential to communicate with non-local research staff. As research becomes increasingly specialised, communication with other specialists in one's own field may become more interesting than communication with local colleagues with a work focus in a different area. ICT facilitates these remote contacts and opens up opportunities for remote collaboration and co-authorship among researchers based at different institutions. Contact to research support-staff such as cyber-librarians ("cybrarians") in distant or even virtual document and resource collections become possible, directly and indirectly (through local staff contacting colleagues through the net). Although the so-called extended research group possibly pre-dated the advent of ICT in academia, it has, nevertheless, been boosted since E-mail-based discussion-lists facilitated the informal sharing of information. This goes well beyond the regular collection of items for a common, paper-based newsletter or the occasional face-to-face meetings of subsets of members of the group. The same is true for the scientific community at large: while on an abstract level, it has always existed and reproduced itself through large yearly conventions, only homepages and distribution lists seem to have the power to activate the potential of worldwide scientific community. Hence, while the scientific community was more like an abstract entity, it now becomes more concrete a communication partner for each member of the community.[106]

Also at the *third* level, i.e. communication with the wider public, one may argue that ICT, in particular the WWW has opened up a new market with new opportunities and a partly new clientele. In earlier days, much of the communication between scholars and laypersons took place through magazines and was hence restricted to those who could afford them and who were active enough to buy them, or through short T.V. programmes. The increasing number of people now having access to the Internet (at ever lower rates) allows both to broaden the potential readership and to add value by going beyond text and photographs, and by offering various levels of technical detail. Hence, the terms of communication between academia and the public are about to be redefined.[107]

[105] These changes will be presented and analysed in more detail mainly in chapter 4 on the spatial dimension of cyberscience.

[106] The changes of academic communication at the second layer are analysed in more detail in chapter 4 on the spatial dimension (e.g. in 4.1 on extended workgroups) and chapter 5 on changing roles in academia.

[107] In contrast to the changes of the two other layers of communication, the relationship between academia and the lay public will not be discussed in detail here (for their consequences on the content of research are comparatively of less importance). There are, however, a few chapters making reference to this aspect, e.g. 6.4.4.2 on the consequences of a changed knowledge representation for the "ivory tower" of 2.4.3 on the web-presence of researchers and their institutions.

(2) Changing media of communication

In the present phase of transition, multimedia communication cannot yet become widespread because of bandwidth and other technical problems. Although Internet chat is a very easy and reliable technology enabling a written form of conversation, it seems not to fulfil the sort of communication asked for by scientists (mainly because of the synchronicity requirement). Therefore, for some time still, conversation in the world of cyberscience may be restricted to *correspondence*, mainly in the new form of E-mail. E-mail has almost replaced the traditional forms, namely letters and fax (cf. 3.3.1). While letters are simply too slow and costly, fax is similar in speed to E-mail but – like letters – involves more steps for preparing a message and is therefore likely to be used solely in cases where original documents only available in print have to be transmitted. In most other cases, E-mail text (increasingly enhanced with layout options similar to traditional letters plus colour) together with the possibility to attach documents of all sorts, including multimedia files, fulfils exactly the needs of scholars.[108]

With regard to *publication*, I observe that most traditional formats now have digital companions or digital competitors. Many journals have a parallel electronic version and new competitors which are published online-only; many scholarly newsletters migrated completely online; textbooks have been enhanced with multimedia CD-ROMs or web-accessible resources; many theses only appear in electronic format on university servers; and a few scholarly E-books are already on the market. If compared to its traditional parent, the pre-print sent to a limited number of peers by mail, "E-pre-prints" stored at world-wide accessible servers, keyworded for selective download and notification services, are something qualitatively new. In some disciplines, this new form of communication has replaced the traditional system of bilateral exchange completely. Furthermore, some of the newly founded E-journals have novel features, unparalleled in the paper world (multimedia enhancements, online commenting, interactivity, open peer refereeing).[109]

In the long run, we would expect less written communication and more face-to-face *conversation* though at distance and with more sophisticated, easy-to-use and reliable tools, transmitting not only speech, but also live video and supported with shared real-time workspaces.[110]

(3) Changing properties of communication

The means of communication based upon the new ICT have similar properties as the traditional means, but in different combinations. Table 1-3 below compares the properties of a few typical means of communication. The non-traditional means are highlighted in grey.

A first observation relates to the dimension of *speed*. On the one hand, the new means do not alter much the available means for conversation. They are and will be "fast", with one notable exception: conferencing will be faster, however not as regards the presenta-

[108] These aspects are discussed in more detail in 4.2.1 and 4.3.3.

[109] As E-publishing is one of the core elements of cyberscience, altogether three chapters of this study are devoted to this subject: chapter 7 is the general chapter on E-publishing in academia; chapter 6 is devoted to the related aspect of knowledge representation (multimedia, hypertext etc.); and chapter 8 focuses on quality control in academic E-publishing.

[110] On the technical aspects of this possible future see chapter 2; a discussion of the feasibility and pros and cons of virtual seminars and E-conferencing takes place in 4.2.2.

tion of papers and debates – they will be as fast or slow as ever – but as regards the convening. It will be much easier to set up and convene people who do not have to travel to a common location. In particular, the very long lead times necessary to make advance hotel and flight bookings possible are superfluous. Additionally, the co-ordination of individual calendars is much easier if travelling times do not have to be added. On the other hand, with regard to the means of correspondence I have already discussed above that the significant properties of E-mail are likely to replace much of traditional correspondence and hence to accelerate it. This effect is even more important with regard to publishing. Although traditional journals (and books for that matter) are gaining in time efficiency when correspondence between all parties and manuscript files are shifted to E-mail as well, there are still considerable disadvantages of all print publications: time for printing and space restrictions. The latter accounts for much of the time lag known from journals with a fixed number of issues per year. E-journals and, even more so, E-pre-prints are much faster with virtually no other time factors than the refereeing procedure (note that even formatting can be done semi- or fully automatically in the digital world).[111]

Table 1-3: Comparing properties of typical traditional and non-traditional media of scholarly communication

	MEDIA of scholarly communication										
	Conversation					Correspondence			Publication		
PROPERTIES of scholarly communication	Face-to-face	Phone	Conference	Internet chat	video conference	Letter	Fax	E-mail	Traditional journal	E-journal	E-print
Fast/ slow	fast	fast	fast (slow)	fast	fast	slow	fast	fast	slow	fast	fast
Synchron/ asynchron	syn	syn	syn	syn	syn asyn	asyn	asyn	asyn syn	asyn	asyn	asyn
Local/ distant	loc	loc dist	loc	dist	dist	loc dist	dist	loc dist	dist	dist	dist
Informal/ formal	inf	inf	inf form	inf	inf form	form	form	inf form	form	form	inf form
Written/ oral	oral	oral	oral	wri	wri oral	wri	wri	wri (oral)	wri	wri (oral)	wri (oral)
Multi-med./ single-med.	multi	single	multi	single	multi	single	single	single (multi)	single	multi	multi
Number of participants	1-1 x-x	1-1	x-x	1-1 x-x	1-1 x-x	1-1 1-x	1-1 1-x	1-1 1-x	1-x	1-x x-x	1-x

Legend: syn ... synchron; asyn ... asynchron; loc ... local; dist ... distant; inf ... informal; form ... formal; wri ... written; multi ... multi-medial; single ... single-medial; 1-1 ... one-to-one; 1-x ... one-to-many; x-x ... many-to-many
The columns in grey are the means of the age of cyberscience.

[111] Speed will be discussed in various places of this study, in particular in 4.3.1 with regard to collaboration, in 7.2.1 on E-publications and in 8.2.4.1 with regard to refereeing.

As regards the *synchronicity* of communication, the new ICT allow for two atypical forms: asynchronous conversation and synchronous correspondence. While traditional conferencing is based on complete synchronicity,[112] digital conferencing does not need co-activity of all participants at all times. This is so because presentations can be stored and listened to later, and discussions can be extended by means of E-mail or web based discussions. The second atypical form is based on E-mail since it can be used to have a near-synchronous written conversation (E-mails being sent back and forth with only small time spans between receiving a message and answering it, which leads to a mixture of correspondence and conversation).[113]

As for *distance*, the most significant change concerns the fact that the new ICT will enable more conversation at a distance. While traditionally, researchers conversed face-to-face and only seldom used the phone, the new ICT add a few attractive distant conversation tools.[114]

If we combine the two dimensions "time" and "space", the following Table 1-4 demonstrates that computer networks de-couple time and space:

Table 1-4: Computer networks redefine time and space

		TIME	
		Synchronous	Asynchronous
SPACE	Local	Face-to-face conferencing	Distributed team work
	Distant	Telephone conferences Tele-, desktop conferencing Shared whiteboard	"Snail mail"[115], fax E-mail, newsgroups Workflow management (groupware)

Source: Based on Johansen (1988, quoted by Rost 1997, 30)

While both the traditional and the new media equally allow for *formal and informal* communication, traditional correspondence and publication tended to be rather formal. The latter is, by contrast, slightly different in the case of digital communication. Both E-mail and E-pre-print archives can be and are used both ways. As for mailing, I hold that electronic messages tend to be less formal than traditional letters. This seems, however, to be about to change as ever more (formal) correspondence "goes online". In some communities at least, the style of E-mails has become more formal recently as E-mails are increasingly replacing traditional letters. So perhaps, we can speak of "style phases" with an informal phase at the beginning and an increasing share of formal E-mails today.

As for publications, one is inclined to draw a clear line between the formal (also: E-) journal publication and the informal (also: E-)pre-prints. Given the rising importance of the E-pre-prints in some disciplines, this clear distinction cannot be sustained any longer. Uploading a manuscript to such an archive, i.e. storing it at a central server and so making it retrievable, is not only aimed at opening a debate about the content but

[112] Note that reading conference papers is not "conversation", but being at the recipient's end of the communication channel called "publication".
[113] See 4.2.1 on a discussion of the properties of academic use of E-mail.
[114] See 4.3.1 and 2.4.
[115] "Snail mail" usually refers to the relative slowness of the traditional mail (surface and air mail).

equally at claiming priority for the results and arguments contained in it. Furthermore, there are plans to make such archives also the basis for formal submission to journals (or novel formats of refereeing) which blurs the borderline between formal and informal even further.[116]

It is often assumed – and indeed the traditional communication means follow this pattern – that all conversation should be *oral* and all correspondence and publication written. This is, however, not necessarily the case if we look at the new media. For sure, face-to-face conversations and conferences are occasionally amended with graphic presentations, but this was no written communication. The new video-conferencing tools, by contrast, present the participants with a multimedia environment that includes as a main communication channel the possibility to exchange documents and to chat in written format alongside the speech channel. Accordingly, the new means in correspondence and publication are not restricted to written communication alone, but may include speech elements as well. There are voice-E-mails, and it is certainly possible to include spoken parts in E-journals and E-pre-prints.[117]

As already noted, the above dimension is only a special case of *multimedia*. A first point to note here is that, as to conversation, both the old and the new media use multiple media. However, not the same. On the one hand, traditional face-to-face conversation differs from its digital counter-part (e.g. in the form of a videoconference) in so far, as the latter will not transmit a number of "channels" (like smell and other non-verbal aspects of a communicative situation). It will probably still take quite some time to improve even video-transmission to such an extent that all details of facial expression will actually be visible for the communication partner. On the other hand, the digital multimedia communication tools seem to somehow reinforce the few transmitted channels while excluding other information (which might, by the way, be less important for some kinds of scholarly communication, in particular for discussing content, as opposed to socialising and "contracting"[118]). Looking at correspondence and publication shows an unequivocal trend from single media (writing) to multimedia. This includes audio and video and even interactive dynamic elements which change or respond according to reader (now: user) action. Publications have the potential to become much richer than they were before. This richness is also due to possible novel presentation formats, e.g. with various layers of information to be accessed via multiple "reading paths".[119]

Finally, the new ICT also have the potential to alter the *number of active participants* in scholarly communication. The most interesting difference relates to publication in traditional versus E-journals. While both are typical one-to-many means of communication, the latter may evolve into a many-to-many channel. In contrast to the rather clumsy mode of reader response allowed by traditional journals (letters to the editor and replicas which appear in one of the next issues, if at all), electronic online publishing provides the opportunity for active participation of both readers and authors in a discourse about a paper (interactive commenting tools).[120]

[116] The characteristics of academic E-mail use are discussed in 4.2.1; on E-pre-prints, their growing importance in some fields and new refereeing systems, see 9.1.3.3, 3.3.6 and 8.2.

[117] On the technical side of this, see 2.4; whether multimedia and video-conferencing can replace the face-to-face feeling is discussed in 4.2.3; on changes of the written academic culture, see 4.3.3, on multimedia in publishing see 6.2.2.

[118] That is, communicating about and agreeing on the terms of the relationship (the rules of the co-operation, for instance).

[119] Multimedia use in academia is discussed at various places of this study, e.g. in 6.2.2.

[120] This is the topic of 6.4.4.1.

(4) Changing functions?

As the four functions outlined above – input, process/production, output and status – are intended to describe researchers' communication in an encompassing way, we should not expect changes in the functions of communication as such. It seems that there is no space for an additional function. To take just one example, whether I notify the scientific community about my recent research results via a traditional journal or an E-journal might be described in terms of different properties of those two means of communication, but it is nonetheless output communication in both cases.

What we should pay attention to, is whether the new means of communication fulfil these functions better or worse, and whether they favour one or the other function. On the *output* side, for instance, many argue that electronic publications are better suited than paper publications to make new knowledge readily available and accessible to the interested fellow researchers because they are faster, cheaper and more varied.[121] Public relations in the research community seems to be gaining in importance as well, not least because of the simplicity of attaining at least some basic level of media presence through, for instance, the WWW (cf. 2.4.3). Talking about *input* communication, there is no doubt that, on the one hand, remote databases and E-publications improve the situation of the information seeking researcher dramatically if compared to the necessarily limited collection of the local library with no other database system than card files. On the other hand, there is the argument that the WWW distorts information seeking behaviour, at least temporarily, as researchers might be tempted to focus only on what they find in the Internet while ignoring what is not there and hence less easily available.[122] As regards *production*-related communication, some hold that face-to-face communication cannot and should not be replaced with electronic means because the richness of the former cannot be matched.[123] By contrast, ICT-based communication has the important advantage that it enables communication with specialists who are simply not easily available locally.[124]

The following Overview 1-9 summarises the main changes of the scholarly communication system:

CHANGES OF THE SCS as regards …

… partners:	• New partners	**… properties:**	• Speed
	• Remote partners		• Asynchronity
… media:	• Going digital		• More distant
	• More formats		• More informal
	• Cheaper		• More correspondence
	• Better access		• More multi-medial
… functions:	–		• Number of active participants

Overview 1-9: Changes of the scholarly communication system as regards partners, media, properties and functions

[121] For a balanced discussion of the arguments involved in this debate, see 7.2.4.5.
[122] On this see 10.2.2.
[123] In other words, they hold that this function cannot be fulfilled with the new means; cf. 4.2.3.
[124] Cf. 4.3.1; for an overall evaluation with a view to the consequences for the quality of the research, see chapter 10.

1.2.4.2 General impact on academia

Based on the above analysis of the potential changes of the SCS, we are now in a position to discuss their potential general impact on academia as a whole (cf. Figure 1-5). I expect impact on (1) actors, (2) structure, (3) processes and (4) products of academia, all of which will be specified in the following. Note that, at the same time, this sub-section may be read as a guide to the substantive impact assessment chapters of Part Three of this study.

(1) *Impact on actors*: Scholarly communication in a wider sense, that is including not only communication among scholars, involves a variety of actors, such as librarians, students, publishers, university administrators, computer department staff, alongside the faculty and other research staff. If the communicative media and their properties change, this is likely to have an impact on those communicating. I hypothesise two types of impact: first, on the communicators themselves, that is as regards their communicative skills; second, on the relationship between them. Since it seems possible that the necessary new qualifications are partially too demanding to be fulfilled (at all or at least sufficiently) at the individual's level, this may impact on the distribution of roles in academia. In other words, traditional roles and scopes of functions may change. The result could be an accelerated shift of functions among existing players as well as the introduction of new players and new functions. Most importantly, we have to expect impact on roles for the following actors: the scholars as researchers and as teachers, the librarians who are becoming "cybrarians", and the academic computer experts.[125]

(2) *Impact on structure*: As the new communication technologies add new communication partners and provide more direct and perhaps equal access to resources and people, the structure of academia is potentially affected, too. Under this heading, I shall therefore discuss structural issues, such as the changing spatial dimension of academia (including the future infrastructure needs and the digital divide; and the impact on the scientific community);[126] the potential impact on status and hierarchy;[127] the changing academic publishing sector (under the label of "de-commodification");[128] and finally the legal problems stemming from the confrontation of an old legal regime with a changing structural environment.[129]

(3) *Impact on processes*: Based on my assumption that the scholarly communication system is a core constituent of the academic enterprise (cf. 1.2.2) as it has a part to play in practically all scholarly activities, I expect an impact on the process level of academia, too. One area particularly affected by changes in the SCS is collaboration, both in quantitative (likelihood of more remote co-operations) and qualitative terms (e.g. new patterns of working together).[130] In general, as we have seen in the previous sub-section (1.2.4.1), the media are cheaper and faster so that potential efficiency gains need to be discussed.[131] Given the, at least preliminary, shift to more media of correspondence (see above), a shift of the academic discourse towards a written culture is a possible scenario.[132] As regards

[125] This is the topic of most of chapter 5.
[126] This is the topic of most of chapter 4.
[127] Cf. 5.5.
[128] Cf. 9.1.3.
[129] Cf. 9.2.
[130] This will be dealt with in 4.3.1.
[131] Cf. 4.3.2.
[132] Cf. 4.3.3.

processes in formal academic publishing, the new tools or the potential lack of quality control as well as the processes of crediting academic output are of particular interest here.[133]

(4) *Impact on products*: Finally, the products of academia will not stay untouched by the changes of the SCS and the other processes within academia. Above all, the incremental move from traditional to digital publishing needs in-depth analysis. E-publishing has a number of new features, offers attractive new formats and challenges, for instance, the system of archiving these academic products. The question of the destiny of traditional, print-based publishing imposes itself.[134] In addition, the digitisation offers a number of alternative models of knowledge representation, such as databases, hypertext and multimedia. What impact will these new designs of cyber-knowledge representation have?[135] Further possible consequences of the new representational formats will be discussed under the next heading, impact on research substance.

The following summarises the general impact of the changing SCS on academia as analysed in more depth in this study:

GENERAL IMPACT ON ACADEMIA as regards...			
... actors:	• Roles changes	**... processes:**	• Knowledge representation
			• Digital publishing
... structure:	• Democratisation	**... products:**	• Collaboration patterns
	• Digital divide		• Different quality control
	• Infrastructure		• Written culture
	• De-commodification		• Efficiency gains
	• Legal problems		

Overview 1-10: General impact of the changing SCS on academia in four dimensions

1.2.4.3 Impact on research substance

Coming finally to the indirect "second generation" impacts of ICT use in academia, I take a further step towards speculation. There is (can be) no scientifically reliable way of finding such second-order consequences of a development in the future (cf. already 0.3.4). Nonetheless, this step has to be taken, but we have to be aware of the thin ice on which my analysis is based here. My conclusions will be mainly based on the (scarce) hints in the literature and on the tentative answers given by my expert interviewees. Again, a grounded theory approach helps me to systematise what can be hypothesised about the indirect impact of ICT (see above 1.2.4).

To elaborate this last element of my analytical framework (the "impact model"), I shall proceed in two steps. (1) I need to define what exactly my dependent variable is; and (2) I have to conceptualise possible impact "routes", that is ways how the changing academic environment may affect the substance of research.

133 This is the topic of the entire chapter 8.
134 And will be dealt with in chapter 7, in particular in 7.3.
135 My tentative answer is given in chapter 6, in particular 6.4.

(1) Substance of research

"Substance of research" is obviously a qualitative category. I am not talking here about the quantity of the research output, in principle. Only if a considerable quantitative change – e.g. concerning average length of articles, number of articles published by individuals, speed of publication etc. – would come close to a quantum leap, would it acquire a qualitative dimension and become relevant in our context.

Further, we may distinguish between formal aspects of substance and those more directly related to content. Both aspects are interrelated, however, and influence each other. For instance, I analyse the impact of a different kind of knowledge representation. At first glance, this is a formal change. I argue, however, that this formal change can have anticipated effects directly linked to the process of knowledge production. At least theoretically, there also seem to be directly content-related changes. ICT might, for instance, lead to more variety or to more unification of academic opinions in a field, to reinforcement of the mainstream or of dissenting sub-communities (see below).

We may ask questions about changes in research substance either in a normative way ("Will the research output be better or worse?") or without reference to any normative yardstick (establishing such a yardstick is in any case difficult). I should only occasionally make reference to normative assessments given by my interviewees, but follow a non-normative route of assessment.[136] In principle, I try to compare the outcome of research with or without the involvement of any kind of ICT and look at *differences in kind or type* or, more generally speaking, in quality (not understood in a normative sense). Since for practical reasons, it is not possible to actually directly compare research with and without the involvement of ICT, I am bound to establish these differences in an indirect manner (via the assessment of expert-observers; see above).

To sum up, my dependent variable "substance" of research is to be understood in a broad, qualitative and non-normative sense. I define

> "substance of research" as the essence proper of the research results, devoid of the form or representation.

I shall also use *"outcome* of research*"* as a generic term for both substance of research and output. The term *"*scholarly *output"* depicts substance plus form (e.g. an entry in a database, a scholarly article, a research note describing an experiment or a lengthy report reviewing and analysing the results of previous literature). "*Content* of research" is sometimes used as a synonym for substance.

(2) Routes of impact

I start from the assumption that, in principle, all types of scholarly activity (cf. Figure 1-1 on p. 24) may have some impact on substance as science and research is to a large degree based on communication in a broad sense (cf. 1.2.2). In particular, those activities in the groups "knowledge production" and "knowledge processing" contribute directly to the substance of research. The main starting-points are to be found in the process (information gathering, data production, co-operation), and on the input and output side (knowledge representation). As regards the process, we may further distinguish between those impacts that are related to methodology and those related to changing work modes. By "work modes" I understand here the practical, day-to-day, carrying out of research,

[136] For my concept of impact *assessment*, see already above 1.2.4.

e.g. whether the research is done collaboratively or not, how fast or efficient it is done etc. By contrast, "methodology" is defined here as the sets of rules of "how to" and as standardised ways how researchers carry out research, e.g. surveys, experiments, literature research either mono-disciplinary or multi/inter/transdisciplinary etc.

In sum, I found three routes of impact on substance of ICT-related changes of the scholarly communication system via changes in academia at large: (a) methodology, (b) work modes, and (c) knowledge representation. These will be briefly presented in more detail below.[137]

(a) *Methodology*-related impact: How new knowledge is created in a scientifically accepted way often involves communication whereby all three layers of communication are affected (above 1.2.2). At the level of communication with the object, there seem to be two main substantive impacts of ICT-based communication: first, the opening-up of new ways of producing results that could not have been produced before (e.g. distributed computing). Second, the networked environment with its multiplied opportunities to access and filter information may lead to a different starting point or initial input-side of the research. A related observation focuses on the creative potential of the wealth of information in the network, the various forms of interactivity and participation. Another possible methodological consequence of ICT use is that it may lead to "de-sealing" of disciplines. I distinguish two variants. First, interdisciplinary work may become more likely since it is easier to get in contact with people interested in the same subject area but looking at the issues from another disciplinary angle. Second, even at the level of communication with the public and the commissioning bodies, we may hypothesise a relationship between the increasing communicative and information space and the type of knowledge production, in particular *transdisciplinarity* (Gibbons et al. 1994).[138]

(b) *Work modes*-related impact: The second set of mechanisms how ICT-induced changes in scholarly communication may impact on substance relates to changes in the way researchers work. Work modes indirectly influence the output in a similar way as different methods do: if you use different tools (methodology) or use the tools differently (work modes), the research outcome (as defined above) will differ. There are certainly also other factors favouring the constant increase of collaborative research (like tying of research grants to the number of collaborators as practised in the EU, the sheer costs of research facilities etc.). However, remote collaboration is facilitated if not enabled to a large degree and hence promoted by ICT-based scholarly communication. While on the one hand the impact of collaboration as such (more perspectives included, more consensual output) will be realised more often as co-operation is facilitated in the age of cyberscience, there are, on the other hand, also special effects of the use of the new medium. Another significant change of scientific work may be its impact on time. Possible effects of the new speed with which information can be exchanged on the outcome of research can be hypothesised via an acceleration of the rhythm of research, via a synchronising effect and by making the publication system more dynamic.[139]

(c) *Knowledge representation*-related impact: This third impact route of new scholarly communication modes on scholarly outcome relates to how scientific knowledge is presented. This has a number of different aspects. On the one hand, there are novel formats, which may have anticipatory effects on the process of writing. For instance, writing *for*

[137] A detailed discussion based on the assessments of my experts is the topic of chapter 10.
[138] On methodological impact, cf. 10.2.
[139] On work modes-related impact, cf. 10.3.

hypertext and hypermedia formats is likely to influence the production process itself; in the digital format there may be standardisation effects; and the preliminarity of the digital medium may influence the finishing stages of writing. On the other hand, the end product has some characteristics that may influence how further research will be built upon, namely potentially increasing transparency and connectivity.[140]

Expanding Figure 1-5 on the chain of impact and including both Overview 1-9 on the ICT-induced changes of the SCS and Overview 1-10 on the general impact on academia, the following Figure 1-6 summarises the complete impact chain with all the specific elements that will be discussed in the rest of this study.

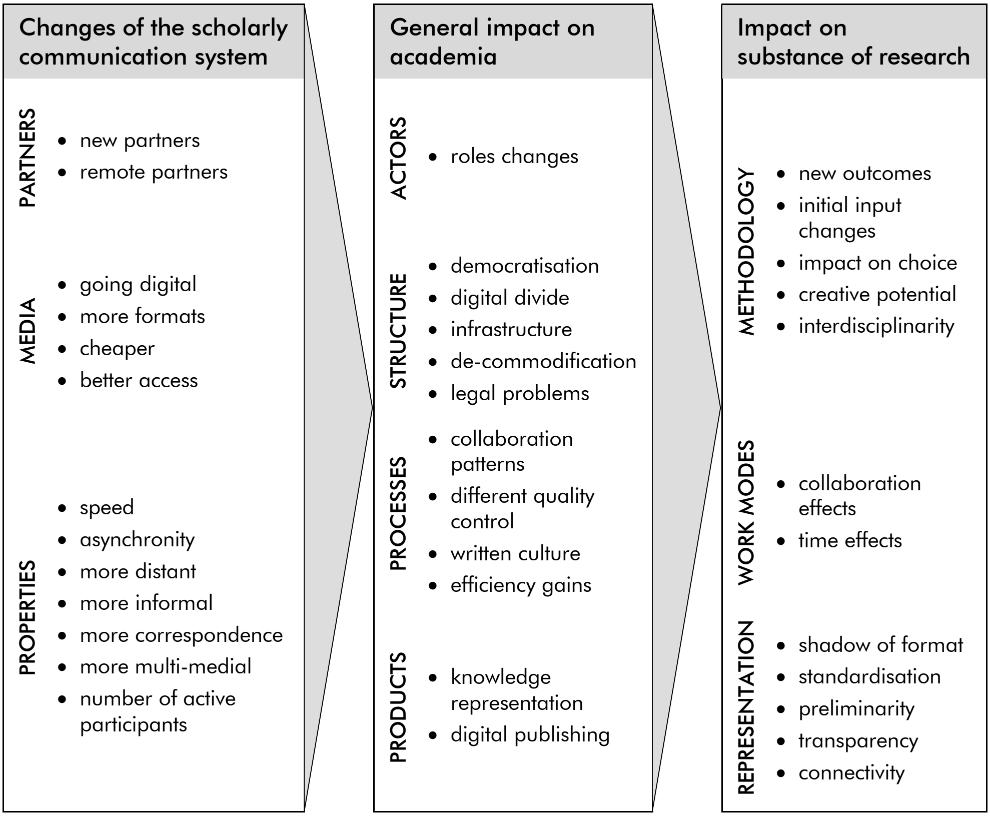

Figure 1-6: The complete chain of impact with details

1.2.5 The complete model

Having presented all elements of my model, I am now in a position to pull them together. In the first step, ICT impacts on the scholarly communication system (rounded corners box in Figure 1-7 below). Inside this box, I explain how ICT is actually shaping the move away from traditional science and research while, at the same time, developing further,

[140] On representational impact, cf. 10.4.

not least influenced[141] by the development it has originally initiated. The so-called "change model" takes due account of a variety of further factors, which, together with the directly ICT-induced changes, produce what I term "cyberscience". In the second step, these ICT-induced changes impact on academia at large, leading to changes as regards actors, structure, processes and products. Finally, indirect consequences are to be expected on the substance of research via three routes, namely methodology, work modes and representation. The following Figure 1-7 (which is an enhanced version of Figure 1-3) is a summary of my overall model:

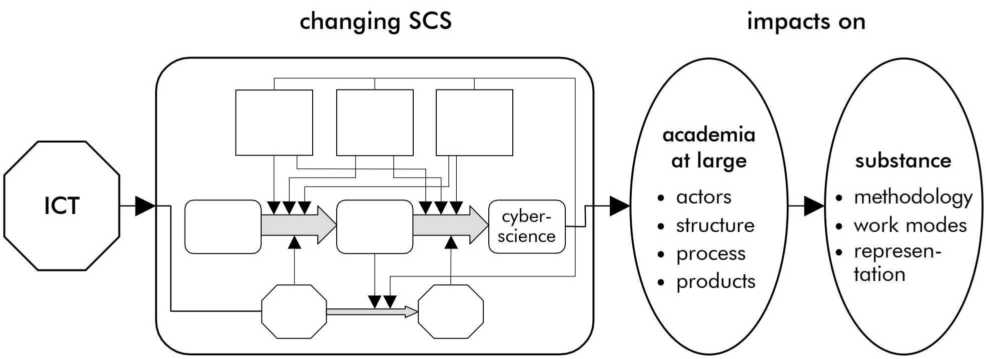

Figure 1-7: The complete model of the impact of ICT on scholarly communication, academia and the research substance

Note that in this model, I am focussing on the impact route "ICT → scholarly communication → academia at large → research substance" as well as on factors mediating this route, but not on other factors influencing (independently from technological changes) both scholarly communication and the outcome. For instance, the various intervening factors not only play a role with regard to the impact route "ICT → scholarly communication" as discussed here, but also directly with regard to scholarly communication in general, regardless of whether technology is used or not. To give an example: if the so-called serials crisis[142] eventually drives commercial publishers out of business (because the academic libraries and university presses take over and establish a new system of formal scholarly communication, cf. Nentwich 2001), this is not (only) due to changes of ICT. This might, nevertheless, be explained by some of the institutional factors discussed here (in particular economic factors). Further scope conditions of my model and results shall be discussed in the overall conclusions (12.3).

[141] Although I would expect, based on diffusion research in the area of interactive technologies (see above 1.2.3), that above a certain critical threshold, this will be a self-reinforcing process, this is not what I mean here by "influenced". Rather I observe (and expect also for the future) that the use of a technology in a given social system not only changes the system, but the changed system also *feeds back* on the further development of the technology.

[142] Severely increasing prices for scientific journals, see 9.1.3.