

Selling technology to the policy sciences

Marketing strategies for specialized scholars

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1. Introduction

In his study of European immigration policies, one of us tends to put a high emphasis on the role of technology (Dijstelbloem & Meijer, 2010). Technology enables new ways to identify immigrants and track their whereabouts. New forms of international collaboration are also facilitated by technological developments. At the same time, policy choices condition the development of new technologies and shape new technological systems. Scholars studying public technologies would argue that changes in European immigration policies cannot be understood without analyzing the development of information systems and new biometrics. These technologies offer certain venues and these offers influence policy development and implementation. Technology matters. Nevertheless, main stream policy scientists are not easily convinced of the relevance of technology. 'It is just an instrument,' they say. These scientists emphasize that we need to study institutional structures, preferences, interaction patterns, socio-economic developments and ideas to understand policy choices. Consequently, in analyses of European immigration policies the role of technology receives little attention and if technology is considered, it is conceptualized as merely an instrument. Many policy scientists simply do not seem to be interested in technology.

This experience in the domain of European immigration policies does not seem to be exceptional (see also Dunleavy et al., 2005). Both the policy analysis and policy studies literature generally overlooks the role of modern technologies in policy change. In well-known text books on policy studies. and subsequently policy change, such as John (1998); Hill (2005); Birkland (2005), technology is hardly mentioned as one of the factors influencing the direction of the policy change. Most explanations focus on either changes in actors' attitudes and convictions (cf. Sabatier & Jenkins-Smith and their core policy beliefs and values, 1993) or changes in institutional structures (cf. Streek & Thelen, 2005). The environment of policy systems usually only plays a role in the form of socio-economic conditions, diffusion or transfer of ideas or crises/punctuated equilibriums.

The lack of attention for technology in the policy sciences is indeed a paradox as modern actual policy-making often refers to technology as the main impetus for policy change. It is, for example, impossible to understand the European union's 'Lisbon Strategy' (EU, 2004) without taking into account the evolution of information- and communication technologies (ICTs) and how this challenges both current industrial policy, as well as the modernization of European government. Likewise, current policy debates on surveillance, biotechnologies, and to some extent also climate change, would be unthinkable without the technological element.

The fact that technological developments may form an impetus for policy change does not necessarily mean that scientists should adopt the same deterministic view on policy as many policy-makers do; a view in which nations are subordinated to some exogenous, almost metaphysical, forces which operate beyond human control. Technology often becomes treated as a 'black box', developed outside of the policy system, which determines the direction of the policy change. The fact that technology also is being shaped by actors within the policy system is overlooked.

While the policy studies and analysis scholars seem to adhere to a rather underdeveloped understanding of technology, students of science and technology studies (STS) have developed more sophisticated approaches to the relation between social systems and technology such as, for example, the structuration approach (Orlikowski, 1992), the technology enactment framework (Fountain, 2001), and the social construction of technology (SCOT) (Bijker, Hugher & Pinch, 1987). These approaches all emphasize the interrelation between technology development and social system.

Science and Technology Studies have influenced policy analyses but they have hardly had any influence on main stream thinking in the policy sciences. Various interesting and sophisticated analyses of the relation between technology and policy are presented in specialized journals such 'Research Policy', 'Science and Public Policy' and 'Technology in Society'. The work published in these journals largely builds upon theories about the social construction of technology, sociotechnical ensembles, technology enactment and structuration. This specialized field, however, seems hardly connected to the main stream research in the policy sciences as published in high-ranking journals.

This paper explores to what extent ideas from Science and Technology Studies about the interrelation between technology and social system have influenced main stream discussion in the policy sciences. Can we indeed see that publications in the key journals in the policy sciences fail to acknowledge the role of technology? Is the analysis of role of technology in policy changed in these journals underdeveloped? The literature review substantiates our idea that technology receives little attention in the policy sciences and is generally underconceptualized. How can technology be 'sold' to the community and policy scientists and how can it be conceptualized in a more sophisticated manner? We will highlight key lessons from the STS literature and suggest how these lessons can receive more attention in main stream journals.

The remainder of this article unfolds as follows. In section two we will describe the methodology we used to select and analyze the literature in the policy sciences on technology as a variable. In section three, we will discuss what role 'technology' is given in terms of policy change on the basis of a literature review of high-ranking journals within policy studies. The following section, four, will present some of the present key approaches to social-technical issues based on STS-literature. In the final section, we discuss how the body of STS literature we have presented can receive more attention in the policy sciences.

2. Methodology for the literature review

The aim of our literature review was, firstly, to describe what role technology plays in the literature in the policy sciences and, secondly, to assess to what extent technology receives attention in the most important journals and, thirdly, to evaluate how the relation between technology and policy change is conceptualized in the main stream literature in the policy sciences. The methodology for our literature review consisted of three phases: the selection of relevant articles, an assessment of the conceptions of the relation between technology and policy change in these articles and an analysis of overall patterns in the selected articles.

We started by selecting the most relevant journal in the policy sciences. We focused on the general journals in the policy sciences to investigate how technology is conceptualized in these journals and not in specialized journals such

as 'Research Policy', 'Science and Public Policy' and 'Technology in Society'. We made an initial selection of fifteen journals, based on their 5-year impact rating as indicated by ISI Web of Science (<http://apps.isiknowledge.com>, retrieved August 15th, 2010). The first fifteen journals, ranking highest within the public administration section, were selected but journals specialized in a particular policy field (*Journal of European Social Policy*, *Climate Policy*, *Journal of Social Policy* and *Environment and Planning C-Government and Policy*) were excluded from the set. The selection method resulted in the following list of eleven journals:

Journal	Impact factor (5y)
Journal of Public Administration Research and Theory	3.738
Philosophy and Public Affairs	3.162
Public Administration Review	2.455
Governance	2.240
Journal of European Public Policy	1.981
Journal of Policy Analysis and Management	1.819
Public Administration	1.810
American Review of Public Administration	1.483
Policy Sciences	1.286
Administration and Society	1.268
Policy Studies Journal	1.157

Table 1. Journal selected for the literature analysis

From these journals, articles containing the word 'technology' in title, keywords or abstract were selected. We limited the period for the literature review to 1999 – 2010. Book reviews and introductions for special editions were filtered, which eventually led to a set of 123 articles, all published from 1999 to 2010. This set was analyzed more specifically to explore whether they actually discussed the relation between technology and policy change on the relation on the basis of the following operationalizations of the two core concepts:

- Technology is defined in a restricted manner as the application of science, crafts or art as an instrument to reach an objective.¹ Examples are knowledge of life sciences to assist human reproduction (in vitro fertilization, cloning) (Timmermans & Scholten, 2006); coal and nuclear technology to produce energy (Sovacool, 2007) or information and communication technology to improve education (Selwyn & Fitz, 2001). Papers based on broader definitions of technology, definition of technology as an organizational method (Meier, 2008; Catlaw, 2005), were excluded from the sample. Furthermore, some articles occurred in the search results through an author affiliation with a university of technology, whereas the particular studies did not deal with technology and were therefore not included in the dataset.
- Policy is a widely used term to indicate deliberate choices of action to tackle perceived problems within society (see Hill, 2005: 6 – 12 for an elaborate discussion of the term 'policy'). This study explicitly deals with public policy and therefore only solutions created by a (local, regional,

¹ We are aware of the fact that 'technology' is sometimes conceptualized much broader, to even include policy (see e.g. Rose, 1999). We think there are good theoretical arguments for this broad conceptualization but we also think this broad conceptualization hampers empirical analyses. For analytical reasons, we adopted a rather restricted definition of technology.

national or supranational) government to solve problems within society were considered. Examples are papers about regulating agricultural biotechnology (Steward, Harding & Day, 2002), stimulating municipal wireless networks (Jain, Mandviwalla & Banker, 2007). This implies that studies that focus on the organization of government were left out of the sample. Intraorganizational affairs are not considered, nor are articles dealing with human resource management examined (e.g. Kim, 2005; Newcomer & Grob, 2004). Studies about external organization of government – generally referred to as ‘governance’ – were excluded as well (e.g. Rogers and Weber, 2010; Löfgren, 2007; Terry, 2005; Hood, 2007) since these studies do not focus on (public) policy as such but on the external organization of policy development and implementation. Furthermore, we did not include studies when these dealt with changing methods to provide or facilitate existing services such as e-Government (Thomas & Streib, 2003) or to ease public participation in policy processes, for example ICT facilitating participation in policy formulation (Myeong& Choi, 2010).

From the original set of 123 papers, 27 articles fell within the formulated definitions of policy and technology.

Journal	Total number of articles	Articles with the term ‘technology’	Selected articles on technology and policy
Journal of Public Administration Research and Theory	265	13	0
Philosophy and Public Affairs	168	0	0
Public Administration Review	744	28	6
Governance	227	9	2
Journal of European Public Policy	743	8	5
Journal of Policy Analysis and Management	375	1	1
Public Administration	465	11	0
American Review of Public Administration	225	24	1
Policy Sciences	182	7	5
Administration and Society	333	12	1
Policy Studies Journal	387	10	6
	4114	123	27

Table 2. Selected articles on technology and policy (1999 – 2010)

The selected articles were analyzed on the basis of a framework with the variables that are most relevant to our conceptual analysis (see table 3). The key variable is the conceptualization of the relation between technology and policy. The other variables provide further information about how these conceptualizations are related to disciplinary backgrounds, type of technology, type of article and geographical orientation.

Variable	Categories
Conceptualization of the relation between technology and policy	<ul style="list-style-type: none"> • Technology as the independent variable • Technology as the dependent variable • Interdependent relation between technology and policy • No conceptualization of technology • Other conceptualization
Discipline of the first author	<ul style="list-style-type: none"> • Political science • Public administration • Public policy • Innovation, technology and science studies • Economics, business, management • Other discipline
Type of technology	<ul style="list-style-type: none"> • Information and communication technologies • Biotechnology • Energy technology • Environmental technology • Defense technologies • Technologies for basic processes in physics • Technology in general • Other technologies
Type of article	<ul style="list-style-type: none"> • Empirical study • Theoretical study
Geographical orientation (of the empirical data are about)	<ul style="list-style-type: none"> • USA • EU • East Asia • Specific countries

Table 3. Framework for analyzing articles on technology and policy

The final step in our literature review was an analysis of overall patterns. We first analyzed the selected articles in terms of their number in relation to the total number of articles, the disciplinary background of first author, the type of technology, the geographical location and the type of study. Secondly, we focused on the central part of our argument: the conceptualizations of the relation between technology and policy.

3. Technology in the policy sciences

3.1. Overview of the literature

We analyzed the selected set of papers to describe the type of knowledge that has been developed about technology and policy. The total number of selected articles was presented in table 1. This table shows that out of 4,114 articles only 123 (3%) refer to technology and only 27 (0,7%) explicitly discuss the relation between technology and policy. This shows that technology is a neglected factor in the policy sciences. Even though technology is generally regarded to be of great importance for the development of our societies, this crucial factor hardly receives any attention in the policy sciences. The relation between policy and

technology is discussed in specialized journals such as ‘Research Policy’, ‘Science and Public Policy’ and ‘Technology in Society’ but hardly receives any attention in the mainstream journals in the policy sciences.

In our description of the selected articles that discuss the relation between technology and policy, let us start with the disciplinary backgrounds of the first author (see table 4)

Discipline (first author)	Number of articles²
Political science	5
Public administration	3
Public policy	5
Innovation, technology and science studies	3
Economics, business, management	3
Other discipline	6
Unknown	2

Table 4. Disciplinary backgrounds of the first author

The table shows that most authors come from the policy sciences (political science, public policy or political administration). Three articles were written by authors in innovation, technology and science studies and three by authors in economics, business, and management. Other disciplines include diverse fields such as Social Science, European, Russian and Eurasian Studies, Philosophy of Science, Environmental Science and Policy and International Affairs. Additionally, one paper was written by somebody working for the Federal Environment Agency.

Secondly, we identified the types of technologies discussed in the selected papers. Table 5 presents the number of articles per type of technology.

Technology	Number of articles³
Information and communication technologies	8
Biotechnology	4
Energy technology	4
Environmental technology	3
Defense technologies	1
Transportation technologies	1
Technologies for basic processes in physics	1
Technology in general	5
Other technologies	1

Table 5. Type of technology

The table shows that most articles discuss the relation between information and communication technologies and policy. A substantial number of articles discuss biotechnology, energy technology, environmental technologies, transportation technologies or technologies for basic processes in physics (i.e. the supercollider). The remainder of the papers discusses other technologies or technology in general.

² The numbers add up to 28 because one author listed both political science and public administration as his disciplines.

³ The numbers add up to 28 since once paper compared policies concerning a technology for basic processes in physics – the supercollider – with policies concerning transportation systems – the space shuttle and intelligent transportation systems.

Thirdly, we analyzed the publications in terms of the geographical locations the empirical work relates to. The findings are presented in table 6.

Geographical location	Number of articles that present analyses for this country⁴	Number of articles that focus on this country only
USA	19	14
EU	5	3
Canada	2	1
France	2	
East Asia	1	1
Japan	1	
Netherlands	1	1
Mexico	1	1
China	1	1
Hungary	1	
Germany	1	
Norway	1	
UK	1	1

Table 6. Geographical location

The table clearly shows that most research focuses on the relation between technology and policy in the US. 19 articles present analyses for the US and 14 out of 27 articles exclusively focus on the US. North America is also represented by papers on Canada. The EU comes second with three papers focusing exclusively on the EU and two papers focusing on individual countries (Netherlands and UK). East Asia comes third with papers about East Asia and China. Mexico is the only country present not from the dominant economic powers (North America, EU and East Asia).

Finally we analyzed the types of studies that were presented in these articles. Were they empirical or theoretical studies? The results are presented in table 7.

Type of study	Number of articles
Empirical study	17
Theoretical study	10

Table 7. Type of study

This table shows that this field is both studied empirically and theoretically. There seems to be a balance between new empirical studies and theoretical analyses: the field is not dominated by either one of them.

3.2. Specific examination of the relation between technology and policy

We categorized the conceptualizations of the relation between technology and policy in three main categories: technology as the independent variable (i.e. techno-determinism), technology as the dependent variable (i.e. socio-determinism) and an interdependent relation between technology and policy. The results of our analysis are presented in table 8.

⁴ The numbers add up to 36 since several articles analyzed more than one country.

Conceptualization	Number of articles
Technology as the independent variable	11
Technology as the dependent variable	10
Interdependent relation between technology and policy	5
Other	1

Table 8. Conceptualization of the relation between technology and policy

The publications that are based upon a perspective of technology as the dependent variable focus on two different government role in the relation between policy and technology: *regulation* and *stimulating innovation*. Regulation of technology is an important field of interest in various publications. Calef & Coble (2007) discuss how the regulation of low emission vehicles has led to different trajectories of technology development in California and France. Other papers highlight the role of government in stimulating technological innovation. Hahm (2008) analyzes how US policies have stimulated technology transfer to South East Asia and Steward et al. (2002) discusses the stimulation of the use of agricultural biotechnology in the USA.

A similar variety of relations can be found in the publications that view technology as the independent variable. The influence of technology on government *regulation* is, for example, analyzed by Maor (2010) who shows how a regulatory agency use the emergence of new technologies to expand its authority. Technological developments in society may also influence government in its *peace keeping* role. Stever (2010) shows how the use of 'lethal technologies' by 'global terror networks' calls for new government security policies. Additionally, new technologies may influence government in its role of *providing key infrastructures* to society. Sovacool (2007) highlights how developments in coal and nuclear energy technology pose new questions for state energy policies.

Only six articles discuss the relation between technology and policy in a nuanced manner as an interdependent relation (Klein, 2000; Nelson, 2004; Timmermans & Scholten, 2006; Hamlett & Cobb, 2006; Eimer, 2008). A closer examination of these articles shows that three different perspectives on the relation between technology and policy have been developed on the basis of different bodies of literature.

- *An STS perspective.* Klein (2000) analyzes three federal programs in the US: the superconducting supercollider, the spaceshuttle and intelligent transportation systems. He criticizes institutional theory and uses theories from the Science and Technology Studies (Bijker et al., 1987; Mayntz & Hughes, 1988) to develop the role of technology and highlight that the nature of technology needs to be taken into account in analyses of these federal programs.
- *A science and public policy perspective.* In their discussion of assisted reproductive technology, Timmermans & Scholten (2006) develop their perspective on the basis of literature on the relation between science and policy such as Jasanoff (1990) and Fischer & Forester (1993), Jasanoff et al. (1995) and Stone (2006). They discuss interdependencies in a nuanced matter and focus mostly on couplings of political and scientific arenas. The journal 'Science and Public Policy' is an important source of information for this approach. A similar perspective is developed by Monpetit, Scala and Portier (2004) who are interested in deliberative democracy and analyze the policy field of reproductive technology on the basis of a framework

about political deliberation. They also refer to Jasanoff (2003) and to the journal 'Science and Public Policy'. Hamlett & Cobb (2006) also study public deliberation in their analysis of nanotechnology. Their conceptualization is similar to the one by Timmermans & Scholten (2006) and Monpetit, Scala and Portier (2006) and they also use the journal 'Science and Public Policy'.

- *A legal perspective on technology regulation.* Nelson (2004) discusses the regulation of technology and privacy. She uses literature from the legal sciences to develop an interdependent perspective on technology and policy: new technologies demand changes to legal frameworks and, at the same time, legal frameworks influence the development and implementation of these technologies. Specialized legal journals such as the 'Berkeley Technology Law' and the 'Michigan Telecommunications and Technology' form important sources of information next to general law journals such as the 'Harvard Law Review' and the 'Stanford Law Review'.

Eimer (2008) makes a combination of the latter two perspectives. He argues that 'transnational communication between scientists, policy experts, and practitioners is often perceived as a key mechanism for the development of common perspectives on regulatory problems' (Eimer, 2008: 276). He builds an interdependent perspective on the relation between technology and policy on the basis of both general literature from the policy sciences and specific accounts from the legal literature. He also uses specialized legal journals such as the 'Virginia Journal of Law and Technology' and the 'Journal of Information, Law and Technology'.

3.3. Discussion

Our analysis of the literature in major journals in the policy sciences confirms the idea we developed upon a reading of handbooks in the policy sciences that technology as a variable is generally ignored. Policy is studied as a political or rational process, environmental conditions and developments in society are taken into account, but technological developments are undervalued. Only a very limited number of articles in the key journals (0,7%) discuss the relation between technology and policy. This is surprising in view of the dominant role that technology plays in most economic and sociological analyses of these times and also the importance that has been attached to technology in the organizational sciences. The relation between technology and policy is discussed in specialized journals and not in mainstream journals in the policy sciences.

The limited number of studies that pay attention to technology as a variable are mostly written by scholars in political science, the policy sciences or public administration. Most studies analyze information and communication technologies but there is also a substantial number of analyses of biotechnology, energy technologies and environmental technologies. There is a strong dominance of studies about the US (but what's new?) and a balance between empirical studies and theoretical analyses.

A closer examination of the conceptualization of the relation between technology and policy reveals a rather naïve conceptualization of this relation. If technology is acknowledged, it is generally treated in a deterministic manner. Nearly half of these papers are based upon a techno-deterministic perspective (i.e. policies had to change in response to technological developments) and nearly half of the papers are based upon a social-deterministic or social shaping perspective (i.e. technologies have been shaped in response to policy choices). Only six papers develop a more sophisticated, interdependent relation between technology and

policy based on an STS perspective, a science and public policy perspective and a legal perspective on regulation.

The analysis highlights the importance of demanding attention for a more sophisticated perspective on the relation between technology and policy in mainstream debates in the policy sciences. We do not try to argue that no efforts have been made at all to develop more sophisticated perspectives on the relation between technology and policy. Articles in journals such as 'Research Policy', 'Science and Public Policy' and 'Technology in Society' often make sophisticated combinations of literature from the policy sciences and STS. These specialized journals, however, have little influence on mainstream discussions and theory development. Key findings from these STS studies are not integrated in theories on policy divergence and policy change. We would like to highlight these key findings and then discuss how these findings could be integrated in the policy sciences.

4. Key lessons from the STS literature

The Science-technology-science (STS) tradition of technology, which today stands as a distinct research tradition with their own conferences (4S) and journals (Technology, Science and Human Nature, Science and Public), grew out of the student protests in the 1960s and 70s against nuclear energy, growing environmental problems, and the constant threat of a nuclear war. The existing social science literature until then had been what Bimber calls a 'normative account of technological determinism' (Bimber, 1994); a number of narratives which bring attention to the dangers in the instrumental and rational ethic embedded in the technology's rationality (cf. Ellul, 1964; Mumford, 1964). The technology here becomes deterministic and autonomous in the sense that it produces a set of norms and values the ethical and political discourse, and instead installs a social regime based on the 'machine rationality'. What really gave this interest for technology and science an academic boost was, according to Bijker (2010), the convergence of the political protests, the sociology of scientific knowledge (cf. Bloor, 1976), and the history of technology (cf. Hughes, 1983; MacKenzie & Wajcman, 1985), where the social construction of technology (SCOT) (Bijker, 1987;1995) can be viewed as an attempt to synthesize the various traditions, and apply a methodological framework.

Although taking different theoretical and methodological strands, they all share a couple of basic premises. First, they all reject assumptions of technological determinism for understanding the role of technology (see, below). Second, they all share an empirical interest in 'thick descriptions' of the technological, social, economic as well as political aspects of empirical cases. They all wish to look into what previously has been seen as the 'black box of technology'. Consequently, they employ 'middle-range' concepts rather than developing 'grand theories' (Bijker et al. 1987). Third, and perhaps most important for this paper, they all discuss the notions of power and politics in their studies. Even though not sharing the conceptions, they do address these questions, and expands the domain of inquiry beyond the realms of formal political institutions.

We will not in this article review the plethora of, mainly post-structuralist, theories which are associated with the STS tradition. Rather, we will address a couple of premises which we suggest can enhance the role of technology in policy studies. We will draw five key lessons from the STS literature. What does every policy analyst need to know about technology?

I. Technology is a key component of policy-making

This might come without saying, but given our results above in our review of the literature it should perhaps be emphasized. Based on Bijker (2006) we can conclude that here are at least three reasons why technology matters to politics, and hence to the study of policy-making. First, technology is a basic element when we discuss social science meta-concepts such as e.g. modernization, post-industrialism, network society, bureaucracy. Already Mumford (1934) described how the erection of clock towers in conjunction with new church buildings in medieval time, came to be an important factor in transforming the (at the time) abstract concept of 'time' to an instrument for disciplining the work force. However, this does not necessarily means that technology per se determines the shape of society; merely that it is a component. Second, technology sets the underlying conditions for policy development. Policy discussions derive much of its cognitive premises from the language, metaphors and symbols of technology. Questions about 'what works', 'what is possible/feasible' etc. is founded in our understanding of available technological options. Third, the use of technology per se underpins the policy process; both in terms of shaping the realms for communication about the policy (in the shape of ICTs), but also as support for decision-making (e.g. through the production of scientific indicators).

II. Technology does not determine policy-making

The idea of technology as something which develops autonomously, following some internal logic detached from the control of external actors, and which shapes society (and thus has a direct impact on policy) is a view that not only isolates everything which is considered to be technological from political influence; it is view that by and large is hard to empirically confirm. Our automobile society was not created by the inventors of the combustion engine, and the development of nuclear energy did not just happen as a result of the development of nuclear physics and their internal (peer-managed) activities. The development of technology is not a linear, rational, evolutionary and problem-solving process in which the successful technology is the one which best solves a social problem. While very few scholars subscribe to this approach (cf Heilbroner, 1967; Knight Jr., 1966), there are signs of this perspective in some of the policy literature where certain invisible forces such as networks, globalization, media etc. are linked to certain technologies (in particular IT).

III. Policy actors interpret technology differently

The twin notion of relevant social groups and interpretative flexibility was first coined in Bijker et al. (1987). The basic idea is that certain social groups attach certain meaning to certain technological artefacts. However, as there is at all times are more than one social group involved in interpreting a technology there is always a certain degree of interpretative flexibility, and we cannot *a priori* assume the hierarchy between them (Bijker, 2010). Consequently, we need to take into account the process by which the artefact is actually constructed by studying those groups of actors which interact with the technology. However, and as argued by Orlikowski (1992), there are limits to the extent of interpretative flexibility. Although there is a significant degree of both technical and social construction involved in the process of interpretative flexibility with respect to a given technology, there is also the case that the same technology once developed and deployed tends to become reified and institutionalized, thus losing its connection with those who constructed it and gave it meaning. As Orlikowski puts it: 'We do not need to physically or socially reconstruct the telephone, elevator, or typewriter every time we use it.' (Orlikowski, 1992: 406)

A perhaps banal lesson for policy studies is that whereas some political actors consider a certain technology to be a political solution might be conceived as a problem by other actors. However, this is in fact not completely acknowledged in the policy analysis tradition. In particular much of the agenda-setting literature (cf. Kingdon, 1984/2003) make sharp distinctions between problems and solutions (or perhaps more precisely between streams of problems and policies), while various actors not necessarily perceive technologies the same way. For example, while a policy community may see a given technology (e.g. nuclear) as a solution (to e.g. energy crisis), there might be other policy communities which see the technology as the problem, or even the reason for the 'crisis'.

In addition to what ready has been said above, it is essential to acknowledge the discontinuity in time and space between on the hand human action which affects technology (*the design mode*) and that which is affected by technology (*the use mode*) (Orlikowski, 1992:408-409). Even though there is always some space for interpretation of any technology, this space becomes limited once the design phase is over. Also, the users' conception of the embedded properties and functionality is affected by the images, rhetoric, ideologies and demonstrations presented by intermediaries such as journalists, consultants, managers and 'power users' (Orlikowski, 2000). The consequence for policy studies is that policy-making regarding 'young' technologies is a hazardous business as there still is a large room for interpretation, and also that the 'relevant social groups' actually reject the technology. One of the authors of this article has at least experienced more than once how students' projects about brand-new technologies even before submission has become obsolete as the studied technology has been judged 'non-functional' by the community it was said to serve.

IV. Technology is an institutional structure in the policy process

To follow up on the users, people's interaction with any technology enacts a 'technology-in-practice'. (Orlikowski, 2002; 2008). Based on many different skills, norms, experiences, habits etc in social life, human actors draw on 'structures' that have previously been enacted when they use technology. These structures, like other social structures, are naturally not predetermined or predictable, and can be reconstituted by the actors interacting with the technology. This change can either happen through mechanisms of *reinforcing*, where the actors enact basically the same structures, or *transformation*, where the actors enact changed structures. The consequence for studying technology and human actors is that it becomes equally important to study the institutional properties embedded in e.g. organizations, political institutions, or social structures, as the those properties imprinted through the design of the technology. An example of the enactment perspective on technology can be found in Fountain (2001) who discusses that in order to understand the use of information technology in governments, we need to understand that the embeddedness of actors in the government in different structures (social, cognitive etc) influences both perceptions, use and design of information technology.

The question of stability and change of these enactments is something which not only Orlikowski discusses in her works, but also a key discussion in the abovementioned SCOT discussion. Here Bijker talks about a process of *stabilization*, during which one interpretation of the technological artefact becomes dominant, and *closure* where the interpretation process comes to a halt and the roads to new interpretation are closed. Bijker's classical example is the design of modern bicycles where one dominant design becomes predominant following a long stabilization process (Bijker, 1995). Although Orlikowski agrees in principle, she claims that we cannot assume that technologies are fully stabilized

or 'completed'. Instead we can only conceive them as fixed black boxes for a period of time (Orlikowski, 2008).

The consequence for policy studies is that technology should be conceived as a structure in society which both enable and constrain human action. However, this structure is shaped through an interactive process in which the users' interaction with the technology 'shapes' the structure (i.e. the technology). Technology is an institutional structure which should be analyzed in more or less the same manner as political and legal structures.

V. Technology is a product of policy and policy is shaped by technology

The two next concepts we can derive from the STS-literature are the SCOT concepts of 'socio-technical ensemble' and technological culture'. Here we move beyond the artefactual level to the social level and address the question of how to understand the relation between the social shaping of technology and the technical building of society. As Bijker puts it: 'Technology is socially and politically constructed, society (including politics) is technically built; technological culture consists of socio-technical ensembles.' (Bijker, 2010:72). Hence, the concepts try to build a bridge between the papers mentioned above who perceive technology as either an independent or dependent variable. The main concept for understanding this bi-directional relationship is the hardness or obduracy of a technology. A technology can be hard in two different ways. First, we can identify a 'closed-in hardness' when human actors are highly included in a *technological frame*. That means that a group of users are 'closed in' by a certain technology and cannot (at least not immediately) see any alternatives to the technology they are used. On the other hand we can identify actors who are more inclined to give up (new) technology at first sign of hindrance; what Bijker calls 'closing-out obduracy' (Bijker, 2010: 70). On a societal level the closed-in hardness can easily be observed in most of the US where a life style without a car is simply not feasible. Equally, there are several examples of technologies where the citizens either can find substitutes, or where they reverse to 'old' technology, in cases where the technology fails to function. The volcano ash disruption in air traffic, following the 2010 Eyjafjallajökull eruption, here represents an example of how stranded airline passengers in Europe rather quickly managed to find alternative means of transportation.

These key lessons are well known in the STS field and they are implicitly referred to in specialized journals on technology and public policy. However, these lessons are not well known in the policy sciences where technology receives little attention. How can these lessons be heard in the broader research community of policy scientists?

5. Marketing strategies for specialized scholars

Why is it so difficult to receive more attention for technology in the policy sciences? In line with Meijer (2007: 238, 239) some explanations can be offered. A common sense explanation is that technology is a complicated. Most researchers in the policy sciences have been trained in political science and public administration and they find it difficult to understand technology. If we put it more bluntly, we could say that they are scared of technology. Most scholars have chosen a career in the policy sciences because they are interested in people and not in science and technology. This predisposition may undermine attention for technology in the policy sciences and, consequently, also threaten the attention policy-makers have for 'technology'.

A more fundamental explanation for the lack of attention in the mainstream policy sciences for findings from studies into the relation between technology and policy, is the specialization of scholarship. One could argue that scientists no longer have the time to connect to various research communities. Specialization has become a hallmark of modern science (Fuller, 2000): scientists need to focus on a specific set of questions, a specific body of literature, specific conferences, specific networks. Specialization may be the key to the success of specialized journals that accumulate knowledge on technology and policy. While specialization breeds success, it will also lead to isolation. Other scholars in the policy sciences hardly read these specialized journals and theories on technology and policy do not find their way into standard textbooks in the policy sciences.

Is the lack of integration of STS studies into the policy sciences a problem? From a philosophy of science point of view, one could argue that specialization is needed for advancing knowledge in specialized 'research programs'. Working within one paradigm can help to develop knowledge. The disadvantage of this perspective is that specialized programs lead to fragmented knowledge production. Fragmented knowledge production is problematic when it comes to tackling problems in the real world. Integration of findings is needed to develop better answers to societal problems. A lack of attention of technology in the policy sciences may lead to experts who develop and analyze policies without a thorough understanding of the role of technology. Specialization is a problem when it comes to transferring knowledge from the academic world to students and practitioners.

How can scholars with a more sophisticated perspective on technology receive more attention in the mainstream policy sciences? Building upon the explanation for the lack of attention and following Meijer's (2007: 240, 241) work, some strategies can be suggested. A first strategy is to strengthen the communicative potential of theories about technology and policy. The five lessons need to be communicated in a 'catchy' manner. Interesting work has been developed but this work has not yet been attuned to research questions in the policy sciences. Theories about structuration, enactment and social construction need to be tailored to the policy sciences. Wanda Orlikowski's (1992) work in the organizational sciences can serve as an example. She managed to translate Giddens' structuration theory to the study of technology in organizations and she managed to raise attention for technology in the organizational sciences. Another example is Jane Fountain's (2001) work in the administrative sciences. She translated Weick's enactment theory to the study of technology in government administration. Why could we not do the same for the policy sciences as Orlikowski and Fountain have done in their fields?

A second strategy concerns an integration of approaches at the methodological level. Policy analyses can be strengthened by broadening the scope to include more actors and structures. Many of the works cited above from the STS field have included research strategies in which the researcher have encountered the 'street-level bureaucrats' of technological design and development, i.e. engineers, and their 'cultures'. There is naturally a challenge to retrieve information from a group of respondents who do not necessarily speak the language of 'politics'. However, their testimonies are often rich in details and do not only entail cognitive statements, but also normative. In fact, the real 'cultural' challenge during, for example, interviews is the New Public Management-infused lingo among engineers, not the technical details. Conversely, STS analyses can be strengthened by broadening the focus to include the political and legal environment. The formal legal and political environment needs to be conceptualized in such a manner that it fits the policy sciences. Such a broad

methodological approach may serve to bridge the gap between the policy sciences and the STS world.

This paper has argued that scholars interested in the relation between technology and policy should make more of an effort to connect their work to the broader community of scholars in the policy sciences. Specialization has helped to advance the field of science and policy studies but hampers the impact of these studies. This balance is tilted to one side: scholars who are interested in technology and policy tend to favor specialized communities. The limited number of publication on technology in the general policy sciences journals was quite astounding. What does this mean for scholars who work on the role of technology in various policy fields? It means that scholars who are interested in technology and policy should make more of an effort to be heard in networks and conferences in the policy sciences. Institutes could develop deliberate strategies for stimulating this kind of behavior and scholars should make an effort to position their work in broader circles. It also means that the discussions with colleagues in the policy sciences should be regarded as highly valuable opportunities to create new connections with the broader field of policy studies. It means that scholars should publish this research not only in specialized journals but also in more general journals. Finally, and this seems most difficult to us, scholars should formulate more catchy perspectives on technology and policy. Latour (1987) has taught us that we need to 'sell' our work to be effective. This paper has highlighted the product (i.e. the lessons from STS), the target group (i.e. the readers of key journals in the policy sciences) and marketing strategies (i.e. catchy theories and integrated methodologies). Now we need to start selling!

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