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Studying uncertainties in sociology and STS

The purpose of this text is to explore and to discuss several strands of literature that are concerned with uncertainties in socio-technical controversies. By "socio-technical controversies" I mean disputes where science and technology play their role: it could be controversies around issues such as genetically modified food, nanotechnologies, mobile phones or radioactive waste. "Uncertainty" as a concept or a phenomenon appears in several different strands of research within the broader field of disciplines that deal with such socio-technical controversies. These disciplines may have different theoretical background, and the definition of "uncertainty" may vary. Consequently, the implications for how uncertainties could be treated may also vary. This text will explore these variations as well as possible similarities in order to provide an overview of available resources to which the empirical research of the thesis will be able to relate. It will pay attention to how uncertainties are defined and framed in the literature, and what implications it has for the ways in which uncertainties could be handled. The reader will find that there is no "conclusion" in this text; the reason is that the purpose of the text is to explore the literature with occasional references to the practices in radioactive waste management, rather than to make an argument.

From delegative to dialogic democracy

The first strand of research that is concerned with dealing with uncertainties in socio-technical controversies can be found within Science and Technology Studies (STS) and it could be represented by the book *Acting in an Uncertain World* written by Callon, Lascoumes and Barthe (2009). These authors point out that scientific and technological development over the last decades has not brought greater certainty (2009: 18). On the contrary, they say that it is a rule rather than an exception that public controversies around techno-scientific issues, especially in the areas of the environment and health, are accompanied by uncertainties (2009: 19). They argue that these uncertainties are *irreducible*, "thereby giving credit to the idea that they are difficult or even impossible to master" (*Ibid.*).

How to make sense of these prevalent and irreducible uncertainties? Callon, Lascoumes and Barthe plot several criteria according to which uncertainties may be characterized: first, they say that uncertainties may be more or less radical (2009: 21). Radical uncertainty is characteristic in that it cannot be lessened in advance, only *a posteriori.* This may be a case for instance when negative side effects in medical treatment can be identified only in the patients' offspring (2009: 22). Second, there is a range of the amount of knowledge about the (negative) effects of a controversial technology or artefact. In some cases, there may be *suspicions* that negative effects are present (2009: 23) – in other words, there is uncertainty about the existence of negative effects, and controversies are centred around the reliability of available information on the issue. The authors say that in this case, systematic investigations are necessary in order to invalidate or confirm the suspicions (2009: 23). In other cases, the existence of the negative effects may be certain, but the causal chain leading to them is uncertain (2009: 24). Here, the subject of the controversy is not only the reliability of the available information, but also what measures should be taken to reduce the negative effects (*Ibid.*). Callon, Lascoumes and Barthe mention that nuclear waste management fits well into this scenario: "no one denies the dangers of storage; the debate concerns how to deal with them." (2009: 24)

Third, Callon, Lascoumes and Barthe point out that although many of the uncertainties related to nuclear waste, GMO or medical treatment seem to be scientific or technical, the

controversies around them "go far beyond solely technical questions. One of the central things at issue in these controversies is precisely establishing a clear and widely accepted border between what is considered to be unquestionably technical and what is recognized as unquestionably social. The line describing this border constantly fluctuates throughout the controversy." (2009: 24-25) Here, Callon, Lascoumes and Barthe argue that the controversies are socio-technical, and that the boundary between what is considered social and what is considered technical is renegotiated and changes over time. Furthermore, uncertainties in the controversies relate not only to the technical aspects: "the protagonists, whose identities vary over time, introduce an indeterminacy that will not be settled until the end of the controversy. Moreover, it is the entry of new actors on the scene that causes the border [between "the social" and "the technical"] to be called into question." (2009: 26). Thus, it can be summed up that the authors assume that first, uncertainties as well as the controversies in question are socio-technical, second, that it is not desirable to try to separate them into social *and* technical, and third, that it is worthwhile for the social scientist to study the making and negotiating of the boundary between what is considered as social and what is considered as technical in the controversy.

For Callon, Lascoumes and Barthe, socio-technical controversies rather than uncertainties are at the core of their interest. Further on, the authors show that the socio-technical controversies that they study are dynamic, and that they can be seen as opportunities for collective learning and exploration (of other technical solutions, for instance). They argue that due to the irreducibility of socio-technical controversies, they cannot be handled by scientists or experts only. Instead, they argue for the use of "hybrid forums" of citizens and experts, in which the dynamic of socio-technical controversies and the overflows (2009: 29) can be handled. Ultimately, they argue that representative democracy cannot contain these overflows, while dialogic democracy based on hybrid forums is able to do so. Thus, in their view, the uncertainties and overflows in socio-technical controversies can be better handled by employing dialogic democracy.

Uncertainty and vulnerability

Another strand within STS that is somewhat concerned with uncertainties is represented by Wiebe Bijker and his concept of the "vulnerability of technological culture" (Bijker 2006, 2009a, 2009b).[1] Bijker departs from the argument well established in STS, that "today's societies are thoroughly technological, and all technologies are pervasively cultural " (Bijker 2009b: 607), which enables him to say that we live in a technological culture. The high-tech character, Bijker argues, is what makes our culture vulnerable: sometimes, the technological systems fail and this failure may result into a disaster with far-reaching consequences, such as in the case of Chernobyl or Fukushima nuclear accidents. Vulnerability is therefore an inherent quality of our technological culture (2009b: 608).

Bijker does not write explicitly about uncertainty, but his concept of the vulnerability of technological culture may be in some ways compared to the concept of uncertainty. Vulnerability refers to some characteristics of a system which make room for the possibility that the system will

1 Both Michel Callon and Wiebe Bijker are representatives of the wider field of Science and Technology Studies, however, they represent different schools within this field. While Michel Callon is largely connected to the "Actor-Network theory" as an analytical approach to studying socio-technical change, (see e.g. Callon 1986, Callon 1999), Wiebe Bijker has participated on formulating another approach, the "Social Construction of Technology" (see e.g. Pinch and Bijker 1984). Despite the fact that these two approaches are in many ways different and provide somewhat different perspective on the studied phenomena, for now I will leave their authors together under the label of "STS", and I will discuss the differences in their approaches where relevant for this work.

not work in the expected way, and may even turn into a disaster. Uncertainty in the most general sense refers to the lack of knowledge about possible states of the world, about the way things are, or about the future consequences of present actions. To put these two notions together, there may be uncertainty about vulnerability: for instance, in the case of geological disposal, we may not know precisely in what conditions the steel or copper canister may corrode, and what consequences over an extremely long time period such situation may have.

What the concepts of uncertainty and vulnerability have in common is that their proponents both argue that they are inevitable. We have seen Callon et al. (2009) argue that some uncertainties are irreducible. Similarly, Bijker argues that vulnerability is inherent in technological cultures. Moreover, both of these concepts are turned by their proponents into something positive. Callon et al. see uncertainty as an opportunity for collective learning and ultimately also an opportunity to improve democratic institutions. Similarly, Bijker argues that vulnerability may be turned into something positive and it may even be seen as a necessary condition for a culture's survival: "only when a culture is capable of learning, innovating, and flexibly reacting to external threats will it be sustainable in the long run" (Bijker 2009b: 608). Here Bijker wants to point out that in order to survive over the long term, a system needs to be flexible enough to be able to react to unforeseen consequences (2009b: 609).

One of the differences between the approach of Callon, Lascoumes and Barthe and the approach of Bijker presented here is that Bijker describes and refers to existing and to a large extent "stabilised" technological systems (such as the train-traffic control system or the Dutch system of storm-surge barriers), while Callon et al. describe ongoing controversies, such as those related to genetically modified organisms or to radioactive waste management. Thus, while Bijker's approach is mostly historical, Callon et al. study technology "in the making". In this sense, it is difficult and probably pointless to compare these two approaches with each other. Nevertheless, it may be useful to put them side by side and to see where they overlap or how they could inform each other.

For instance, let us accept the argument of Callon et al. that some uncertainties are irreducible and inevitable, as well as Bijker's argument that vulnerability is inherent in complex technological systems and that vulnerability may also bring flexibility which is necessary to react to unexpected circumstances. If we accept these arguments, we may see vulnerability of a system as a 'tool' to cope with unexpected events, which may be the outcomes of the uncertainties in the planning process. Thus, flexibility of a system, which goes hand in hand with vulnerability, may be regarded as a tool to cope with uncertainties.

In this sense, the requirement for flexibility seems to be in contradiction with the aim of the current Czech radioactive waste management strategy, which aims to create a final disposal for radioactive waste. Indeed, Barthe (2010) gives an account of the history of the French radioactive waste management programme interpreted in similar terms: Barthe shows that the establishment of the concept of irreversible geological disposal meant first, that uncertainty was transformed to (calculable) risk and second, that responsibility of the long-term safety was delegated to geology and geologists (2010: 12-15). However, in the course of time, the concept of irreversible disposal gradually started to be challenged precisely on these grounds, i.e. on the possibility to calculate risk and to delegate responsibility to geologists, which led to the development of the concept of reversible geological disposal (2010: 16-18). Nevertheless, Barthe argues that once we speak of geological disposal, its reversibility can always be only temporary, limited in time (2010: 19). Its step-wise decision-making model creates a sense of control, but sooner or later, a final step is expected and the disposal will become irreversible. Moreover, the particular steps may not be equal in terms of how far they move the solution to irreversibility. Thus, Barthe goes in his argument even further and proposes an "iterative" model for radioactive waste management, which consists in "enduring" above-ground storage, ongoing research and periodical reconsideration of what to do

with the waste (2010: 22-25). Such a model, according to Barthe, also implies employing "dialogic" democracy – in comparison with delegative democracy, which is implied by the "clear-cut decision-making" associated with the model of irreversible geological disposal (2010: 20).

Following Callon et al. and Bijker's arguments presented above as well as Barthe's interpretation of the history of the French radioactive waste management programme, we can see the move from irreversible to reversible geological disposal and then to "enduring storage" as a move from from one solution to another which is more vulnerable, but at the same time more flexible and able to cope with uncertainties. Barthe articulates this when he says that the enduring storage model "leaves the future open" and "permits new terms for decision-making and a new political stance in the face of uncertainty" (Barthe 2010: 24).

Uncertainty and risk research

Another strand of literature that pays attention to uncertainties is the one concerned with risk research and management. In this field, researchers have been developing typologies of risk and adequate strategies for dealing with these risks. For instance, Klinke and Renn (2002) distinguish between "simple", "complex", "uncertain", and "ambiguous" risks, with consequences for how these risks should be treated (see also Renn and Graham 2005). Such a distinction implies that uncertainty is regarded as a specific category and a special condition within risk management: according to this categorisation, there are risks where uncertainty plays a role, and there are risks where it does not. Such categorisation has recently been disputed: de Vries et al. (2011) argue that risk problems may move between the four categories, and therefore policies based on this distinction are misguiding (2011: 497). They propose to turn the problem around – to put uncertainty forward while considering risk a special case, "namely as a condition that may come about when the efforts to translate uncertainty into (calculated) risk have been achieved successfully." (Ibid.) Such perspective resonates with Barthe's account of the history of the French radioactive waste management discussed above, in that Barthe points out that the concept of irreversible geological disposal meant reducing the uncertainties about possible worlds into calculable risks, and it was later refused precisely on these grounds (Barthe 2010: 16-18).

The precautionary principle as a way of coping with uncertainties

An often-mentioned strategy for dealing with uncertainties is the precautionary principle. For instance, Renn and Graham mentioned above suggest that precautionary approach should be applied in cases of uncertain risks. They say that "the main management philosophy for this
risk class is to allow small steps in implementation (containment approach) that enable risk managers to stop or even reverse the process as new knowledge is produced or the negative side effects become visible. The primary thrust of precaution is to avoid irreversibility (Klinke and Renn 2002)"
(Renn and Graham 2005: 46). However, as Barthe's (2010) view discussed above points out, such strategy implies that all steps in the process are reversible. But this condition is in conflict even with the concept of "reversible" – but *final* – geological disposal.

Apart from that, there is another issue with the precautionary principle, identified by van Asselt and Vos and which they call "the uncertainty paradox" (van Asselt and Vos 2006). Van Asselt and Vos argue that most of the legal implementations of the precautionary principle include a "knowledge condition [that] implies that lawyers and policy-makers appeal to scientists and experts for some kind of plausibility 'proof'" (2006: 317). In other words, policy-makers need to ask scientists and experts to provide them evidence that uncertain risks are present. However, this is in contradiction with the notion of radical uncertainty, which we cannot have a decisive evidence about. At a more general level and with the help of Forrester and Hannekamp (2005), van Asselt and Vos interpret the uncertainty paradox as a situation where on the one hand, the possibility of

radical uncertainty in science is acknowledged, while on the other hand, "science is still expected to tell the truth about uncertain risks" (van Asselt and Vos 2006: 318). Van Asselt and Vos imply that in order to get out of such situation, the departure from the traditional model of decision-making is necessary (2006: 317), and apparently they do not see the described implementation of the precautionary principle as sufficient in this respect. Nevertheless, precautionary principle is quite often called for as a tool to mitigate uncertainties, and it is also sometimes mentioned in direct relation with the planning of geological disposal for radioactive waste.[2]

Increased public participation as a way of coping with uncertainties

We have seen that when talking about uncertainties, many researchers articulate the need to improve the existing decision-making institutions. It seems that this call is being answered in the field of radioactive waste management. After many failures to find a suitable and "socially acceptable" site for geological disposal, many national radioactive waste management programmes emphasize the need for increased "public participation" and "transparency". A number of mechanisms to increase transparency, trust and public participation in the process of planning GD have been proposed (e.g. Dubreuil et al. 2010 or Laes et al. 2009). The reasoning behind these efforts may partly be that increased public participation and transparency will increase the legitimacy (and often also the probability of success) of the process of planning geological disposal (cf. Andersson et al. 2004). One of such mechanisms, the RISCOM model, is also being implemented in the Czech Republic (cf. Vojtěchová 2009).

On the one hand, the efforts of increased public participation resonate with the calls for "dialogic democracy" of Callon, Lascoumes and Barthe. On the other hand, critique towards the ways in which similar efforts are being carried out has recently appeared within the field of STS. For instance, Sundqvist and Elam show that at a European level, public participation in radioactive management is carried out as a goal in itself rather than as a means to reach better articulation of issues in question (Sundqvist and Elam 2010). In relation to uncertainties, Soneryd has shown that in deliberative arrangements, scientific uncertainties are sometimes left out of the debate and delegated to experts (Soneryd 2007).

Thus, it seems that on the one hand, public participation procedures may be sometimes seen as means of coping with uncertainties; however, these may be "social uncertainties" that the implementers face and that are dealt with by means of "increasing legitimacy", while at the same time, scientific uncertainties may be effectively left out from the debate. One can assume that issue articulation plays a crucial role here (cf. Marres 2007), as well as the way participation is carried out in practice.

Common themes and differences in research on uncertainty

It is difficult (and perhaps pointless) to compare different strands of research that are concerned with uncertainty due to at least two reasons. The first is that the authors presented in this text come from different theoretical and methodological traditions. The second is that "uncertainty" is a very broad term, which may refer from the lack of knowledge about some physical phenomenon, to the lack of knowledge of what a specific group of people will do, to the lack of knowledge about how society at large will evolve. Nevertheless, it is possible to summarize some final observations which may be useful for further work on the thesis.

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2 Callon, Lascoumes and Barthe suggest that the proliferation of the precautionary principle into policies was due to the "intense activity of research in the wild in which professional legal experts have been quick to take part." (Callon, Lascoumes and Barthe 2009: 191), and they add that "this explains the profusion of definitions, but also their instability" (*Ibid.*)

First, all of the authors discussed above accept that uncertainty is characteristic of our world, and that many uncertainties are related to science and/or technology. While some authors emphasize the irreducible character of some uncertainties, others assume that uncertainties may be dealt with (for instance transformed into calculable risks). Second, it is worth noting that although uncertainty is generally regarded as something undesired and something that people need to "reduce" or "cope with", some authors find positive aspects about uncertainty, such as the possibility for collective learning and exploration (Callon, Lascoumes, Barthe) or innovation (Bijker). Third, it seems that while some authors or disciplines (such as that of risk management) assume that uncertainty can be dealt with using the tools of science and policy in the "modernistic" sense, others argue that (at least in some circumstances) we need to rethink the role and the possibilities of science and delegative decision-making. At the same time, the latter view does not expect that there is a universal solution to cope with uncertainties. In respect to this view, it seems useful to study how uncertainties are in specific cases articulated, how they unfold in time and what boundary work is going on as the socio-technical controversies where uncertainties play a role develop.

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