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RESEARCH ARTICLE

The role of risks and uncertainties in technological conflicts: three strategies of constructing ignorance

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How are the conflicts over the use of certain technologies – such as biotechnology, nuclear energy or nanotechnologies – being solved? What are the methods used by conflicting parties to assert their definitions of reality? What role do uncertainties and risks play in these conflicts? How are they treated? What strategies are used by proponents and opponents of a controversial technology to persuade the public and decision-makers? This article aims at finding answers to these questions by looking at technological conflicts from the perspective of the reduction of risks and uncertainty. The lesson drawn from the study of ongoing and past conflicts over controversies in technological development should help to better understand the dynamics of conflicts focused on converging technologies. The reduction of uncertainty is analyzed from the perspective of the sociology of non-knowledge and ignorance. It is argued that new areas of non-knowledge are being created by reducing uncertainty and risks in technological conflicts.

Keywords: risk; technological conflicts; uncertainty; ignorance; non-knowledge; controversies

Introduction

Ever since Ulrich Beck's *Risk society* was published in 1992, claiming that technological development is the source of social conflicts has been quite a platitude in the social sciences. Over the last few years we have had the opportunity to observe quite a number of technology-related conflicts, such as the GMO issue, the BSE crisis and bird flu. What is more, some "classical" technological conflicts, which might no longer seem to be topical, turn out to still be virulent: discussions concerning nuclear energy seem to be even more heated than previously, especially since the debate on global warming has made some state governments look more closely into the issue of nuclear energy. New conflicts still lie ahead, as we keep developing more innovative technologies, such as nanotechnologies or techniques in reproductive medicine. In the near future, too, we can expect the emergence of new technological conflicts concerning converging technologies. Biotechnology has already become a symbol of modern technological controversies, whereas nanotechnology shows a significant potential to focus public unease with science development on converging technologies.

The scale of technological conflicts demonstrates that modern societies still have a problem with solving them and controlling their course. Not many examples of

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technological conflicts in the past could be found which were solved, or at least ended peacefully, because the social tension caused by technological progress was effectively relieved. One of the reasons for this fact may be the extent of uncertainty and risk associated with many of these controversial technologies. It is possible to regard technological conflicts as caused by uncertainty related to the problem of possible harmfulness (as in the case of risk) or concern about the way a given technology works, for whom it is profitable, what influence it may have on the "outside world", what changes in social relations it can occasion or – last, but not least – how it may change the future.

These questions have to be answered in order to reduce the uncertainties and risks associated with the controversial technology. Therefore, every conflicting party endeavors to find strategies to reduce the hazards according to its own interests. Such questions constitute the crux of many technological conflicts: both the "classical" ones, such as conflicts over nuclear energy or waste disposal, and "modern" ones over biotechnology. That is why it can be assumed that in the case of cogno-, nano- or information technologies similar conflict-resolving mechanisms can be expected in the future. From this perspective, technological conflicts present themselves as attempts to reduce uncertainty and to establish one dominant definition of a given technology, free of uncertainties creating scope for dissent and conflict renewal.

If we accept these assumptions, it can also be conjectured that the more uncertainty there is, the more difficult it is to solve a conflict. There seems to be a consensus about the fact that converging technologies are laden with many uncertainties as to their possible causes and interrelations (cf. e.g. Uskoković 2007). Looking at instances of how risks and uncertainties have been reduced in today's technological conflicts may therefore turn out to be useful tool not only for analyzing further conflicts in the area of converging technologies, but also for influencing them actively in the desired direction. In other words, from the examples of past and present conflicts we can learn how to deal with future ones. The purpose of this article is to present a model describing the defining strategies taken by the participants of technological conflicts in order to solve them. We have called it a reductive model, as it is based on reduction procedures, such as reducing conflict complexity, reducing risk and reducing ignorance. The first step will be to introduce some basic concepts concerning technological conflicts and the reductive conflict-solving model. Then, reference will be made to the sociology of scientific ignorance, which offers the theoretical background for analyzing reduction processes. The next stage will be to introduce two risk-reduction degrees and three conflict redefining strategies used in our model. Finally, a catalogue of reduction techniques will be presented within each strategy.

Technological conflict

A "technological conflict" will be defined here as a kind of social conflict deriving from a social debate over the consequences of using a certain technology. Using (or ceasing to use) this technology is perceived as threatening the interests of at least one actor in the conflict. Some examples of technological conflicts are presented in Table 1.

The model presented in this article is based on the assumption that the complexity of technological conflicts is one of the reasons why they are so difficult to solve. This complexity is mainly caused by the high degree of uncertainty and risk associated with controversial technologies, which makes it impossible to identify all their implications and interrelations. This complexity is inherently linked to the fact that many modern

Table 1. Some examples of technological conflicts

Issue	Conflicting parties	Examples
Using nuclear energy	Ecologists, local communities, some political parties vs. energy industry, state governments, scientists	Dispute over the construction of new nuclear power plants Power plant waste transport through Germany Local protests concerning the construction of nuclear waste disposals
Development of biotechnology	Part of the public and the media, religious groups, some state governments vs. biotechnological enterprises, scientists	Banning the cloning technique and certain kinds of genetic research
Genetically modified organisms (GMOs)	Farmers, ecologists, part of the public vs. biotechnological enterprises, state governments EU vs. USA and WTO	GMO-free region campaign in Europe. Attempts to ban the cultivation of GMOs in the EU
Regulating water systems	Ecologists, part of the public and the media vs. state governments	Constructing dams and artificial water reservoirs
Global warming	EU, ecologists, the public vs. USA, Russia, China, India, the industrial sector	Kyoto Protocol
Mobile phones	Part of the public, local communities, some scientists vs. telecommunications companies, state administration and scientists	Local disputes over the construction of telephone masts
BSE	UK vs. EU, EU vs. USA, the public and the media vs. state governments and cattle breeders	Proliferation of BSE in Europe in the 1990s
Cure for AIDS	Governments of some African states vs. WHO and medical enterprises	Doubts concerning the use of AIDS medicines. Patent issue

technologies, especially "converging technologies", encroach on social life and transform it utterly.

As a result, technological conflicts are not (as the deficit model of Public Understanding of Science would like to see them) simple conflicts stemming from the fears shared by sections of society, afraid of the possible negative effects (real or imagined) of introducing certain new technologies, such as genetic engineering or using stem cells to generate organs. Technological conflicts concern the very nature of the social change caused by technological innovations (Felt and Wynne 2007). It might be said that they start when people become aware that the products of technological progress are not innocent tools, used in order to make our lives easier and more pleasant, but an important factor stimulating social change and influencing social life, the choices we make for the future, types of human relationships and the relationship between human beings and nature.

According to Felt and Wynne (2007), innovations generated by science are never purely technological. Their nature is always both social and technological. On the one hand, they can only be implemented effectively when the structure and organization of society are "compatible" with the very nature of each innovation. On the other hand, through their implementation and development, innovations always cause a change in the social context. As a result, as Felt and Wynne point out, describing modern fears caused by technological progress cannot be merely reduced to the notion of risk. These fears concern the nature and the consequences of each innovation implemented. The fact that technological conflicts go beyond the pure notion of risk makes them even more complex and multi-dimensional, as we are dealing simultaneously with many different issues (their harmfulness, moral and ethical questions, political and economic problems, group interests, individual rights, etc.). Their complexity makes them difficult to solve, which is why it can be assumed that one of the basic strategies of every conflicting party will be to reduce the technological conflict in accordance with its interests. The present article is an attempt to look at the dynamics of technological debates using a reductive conflict-solving model, which should be helpful in describing and understanding their nature.

The theoretical background for the model will be based on some elements from Pierre Bourdieu's symbolic fields theory. Reducing conflict complexity consists of attempting to validate the definition of the technology at stake, formulated by every participant in the conflict. These definitions include the technology mechanisms, its consequences, its risks, but also the postulated hierarchy of goals and values, types of human relations, development projects, visions of the future, desired forms of social structure and visions of a utopian "good life". In other words, the participants in technological conflicts present wholesome definitions of reality resulting from the implementation of every socio-technological innovation and attempt to validate them.

At this point we could refer to Ulrich Beck's theory of "structures of defining", which he compared with the functioning of production relations in the industrial societies. The power to define and say what is harmful and what is not, to what extent and starting from what quantities, how to behave in the face of possible dangers and how to contain and regulate them, is one of the most fundamental political resources. This is due to the nature of the dangers themselves, which are always symbolically mediated and can therefore only be cognized indirectly. As Beck wrote in *Risk society: towards a new modernity* (1992, p. 27):

> That which impairs health or destroys nature is not recognizable to one's own feeling or eye, and even where it is seemingly in plain view, qualified expert judgment is still required to determine it "objectively". Many of the newer risks (nuclear or chemical contaminations, pollutants in foodstuffs, diseases of civilization) completely escape human powers of direct perception. The focus is more and more on hazards which are neither visible nor perceptible to the victims; hazards that in some cases may not even take effect within the lifespan of those affected, but instead during those of their children; hazards in any case that require the "sensory organs" of science – theories, experiments, measuring instruments – in order to become visible or interpretable as hazards at all.

It seems, though, that Beck's concept of defining risk does not allow for the complexity of technological conflicts and concentrates too much on the harmfulness of every technology (cf. also Lau 1991).

According to Bourdieu, technological conflicts can be seen as struggling to validate the definitions of reality presented by every conflicting party. The struggle affects different fields, depending on the nature of the conflict, and may include an attempt to prevent validating a certain definition of reality within one field and shift it to another. These are so-called "medicalization" processes, where the definition of life, its beginning and its end, is no longer an ethical, moral or religious issue and becomes a purely medical problem (which actually means that it has been shifted from one domain to another). The struggle to validate one's definition of reality often concerns the right to define some new phenomena resulting from technological progress. Several questions arise that could serve as examples, such as: how to interpret the transplant technologies; which domain to use for describing nanotechnologies; is growing GMOs an economic, political, scientific or rather ethical issue?

The objective of each definition of reality presented by conflicting parties is to cover all the controversial phenomena and to gain exclusive rights to define them. As a result, the complexity of the problem is reduced in a way to suit the needs of each actor. This is why developing countries will view the global warming dispute as a purely economic problem, setting aside its ecological aspect. Some African countries will tend to perceive propagating condoms and the anti-HIV campaign as a reflection of political relations between the North and the South, ignoring the health problem (and, therefore, defining AIDS as nothing but an illusionary threat). The Catholic Church will perceive abortion as breaking religious rules, ignoring the social aspect of the problem. Struggling for the right to define requires specific defining strategies which aspire to influence the form of the conflict and the way it is solved. As a result, the conflict is redefined in a way that reflects the interests of the actor: technological conflict now becomes economic, ecological or scientific. Figure 1 presents the reductive conflict-solving model presented in this article.

The sociology of scientific ignorance

The sociology of scientific ignorance (SSI) sprouted from the sociology of scientific knowledge (SSK) in the early 1980s (Stocking 1998). It did not aspire to replace the existing research tradition. What it wanted to do was expand this tradition and complement it with a previously ignored dimension, the "shadow-side of knowledge" (Stocking 1998), i.e. what science did not know. Rather than being a new subdiscipline of

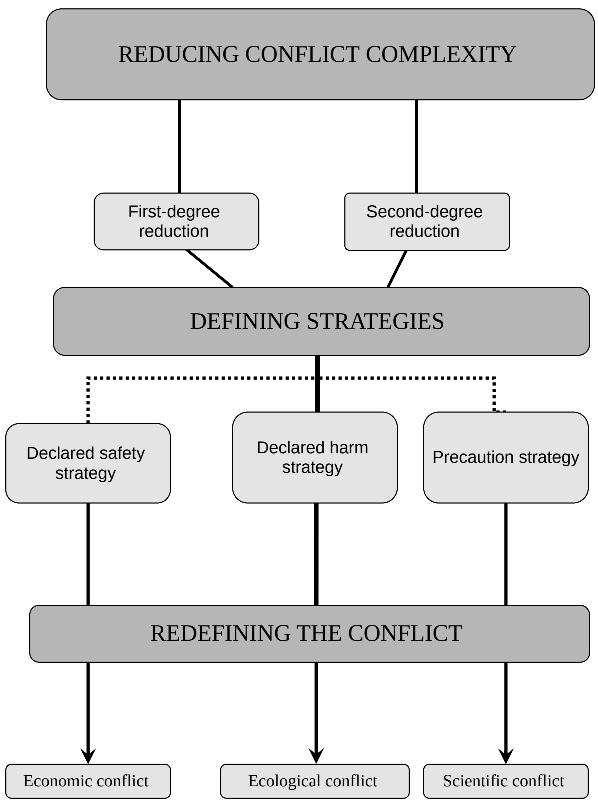

Figure 1. Reductive model of solving technological conflicts.

the sociology of knowledge, it was a redirection. Several works emerged within this new current, most of them theoretical (cf. Smithson 1985, 1989, 1993; Ravetz 1986, 1987, 1990; Funtowicz & Ravetz 1991; Stocking & Holstein 1993; Beck 1996; Michael 1996; Walton 1996; Japp 1997; Stocking 1998; Böschen 2000; Wehling 2001, 2004).[1]

This idea is based on the observation that ignorance has lost its natural "innocence", both epistemological and social. Ignorance is no longer a natural state, a shadow zone dissipated by scientific discovery and a mere starting point for scientific endeavor; it is now problematized as a social construct, a product of knowledge-generating processes that serves specific political functions (Wehling, 2004, p. 36). This is how Peter Wehling describes the new approach to ignorance (pp. 36–37):

> Whoever reduces ignorance to the incognisability of natural relations is also reaching for a specific figure of argumentation and placing it in either the public or the scientific debate on the reasons for the lack of scientific knowledge. And by so doing he evokes the question of the meaning of "incognisability" (fundamentally incognisable? incognisable at this particular moment? incognisable due to insufficient scientific and technological advancement?) and the factors leading to this incognisability.

The reasons for incognisability are sought not in the nature of reality itself, but in the institutional and methodological barriers within science and its environment. As in the sociology of scientific knowledge, where scientific knowledge is not viewed as something objectively given in nature and merely discovered by scientists, but as the outcome of specific social, knowledge-generating processes, so too scientific ignorance is viewed as the product of social relations. It is subject to negotiation among scientists and between scientists and other actors (sponsors, regulating and controlling institutions, consumers) as something which is shaped by specific interests and either modified and accepted or rejected. Placing ignorance on the same analytic plane as scientific knowledge meant extending the famous symmetry principle of the so-called strong programme of the sociology of knowledge.

Knowledge is not just the opposite of the lack of knowledge, the realm of the yet unknown, reduced by scientific progress. On the contrary, researchers have coined the term "science-based ignorance" (Ravetz 1986), conceived of as the realm of relevant ignorance generated by scientific and technological progress. "Now we face the paradox that while our knowledge continues to increase exponentially, our relevant ignorance does so even more rapidly. And this is ignorance generated by science!" (Ravetz 1986, p. 423, after Wehling 2004, p. 44). Ravetz specified his concept of ignorance generated by science the following way:

> This is an absence of necessary knowledge concerning systems and cycles that exist out there in the natural world, but exist only because of human activities. Were it not for our intervention, those things and events would not exist, and so our lamentable and dangerous ignorance of them is man-made as much as the systems themselves. (Ravetz 1990, p. 217, after Wehling 2004, p. 44)

Here the sociology of scientific ignorance touches on a problem which is also important for the study of technology, where the focus is on the fact that, as science and technology develop, the possibilities of technological intervention become increasingly broader. Hence, on the one hand, their possible consequences become more and more far-reaching and, on the other, they grow more and more difficult to foresee.

To summarize the most salient aspects of the sociology of scientific ignorance from the point of view of this study on technological conflicts, attention should be drawn to the fact that this is not sociology of ignorance in the strict sense, but sociology of scientific ignorance.[2] This observation seems to be based on the tacit assumption that, once science has described and explained a phenomenon, this phenomenon is automatically known and passes from the realm of ignorance to the realm of knowledge. Meanwhile, as far as many features of today's technologies are concerned, they remain within the domain of scientific ignorance although they have been scientifically cognized (more on this later). In other words, they are invisible, not because they continue to elude scientific cognizance, but because they are subject to extra-scientific processes and phenomena. These processes and phenomena must be described if we want to gain a comprehensive view of the mechanisms of conflict reduction.

This aspect of the sociology of scientific ignorance goes hand in hand with its epistemological attitude: the focus here lies on the nature of scientific cognizance and the reasons why certain phenomena escape it, whereas it seems to be only one of the many important questions concerning the development of areas of uncertainty, risk and ignorance in society.

A third major aspect of the research paradigm under discussion here is its focus on unintended and subconscious mechanisms of ignorance generation and lack of interest in the role of specific social actors and their interests in the social construction of ignorance (Wehling 2004, p. 55). A pertinent illustration of this approach is Wehling's analysis of the history of Freon and its effect on the ozone layer. In his attempt to discover how it could happen that for half a century nobody noticed that Freon was destroying the ozone layer, Wehling completely ignores the interests of the manufacturers of this substance. Even when he writes about the most controversial period, lasting more than a decade (from 1974, when it was first hypothesized that Freon might be harmful, to publication of the Montreal protocol in 1987), he fails to see that one of the determinants of the prolonged denial of the detrimental effect of Freon on the ozone layer was the strategy adopted by Freon's main manufacturer, DuPont, who adamently refused to accept this hypothesis until 1986 (cf. Smith 1998).

This is why it seems that, in a larger perspective and without contradicting the very nature of SSI, there can be talk of the social construction of ignorance. Socially constructed ignorance will concern, for example, some diseases such as malaria, tuberculosis or cholera, which are called "neglected diseases".[3] Their existence in today's world is often explained by the fact that the medical industry has no interest in doing any research on a cure or vaccine to eliminate them. This situation results from the fact that these diseases mainly affect Third World countries which are not target groups for pharmaceutical concerns. Among all the new medicines introduced to the market over the last decade, only 1% are intended to cure tropical diseases. The persisting ignorance of effective ways to combat malaria turns out to be a social construct determined not only by the objective nature of reality (i.e. the complexity of the problem), but mainly by the interests of specific social groups.

Reducing conflict complexity

Definitions of reality formulated by the conflicting parties trying to validate them are based on a two-stage reduction:

(1) *First-degree reduction*: reducing conflict complexity to physical risk. This stage consists of reducing the conflict to fears concerning the possible physical and biological hazards (a technology bears certain risks for human life and health and threatens nature).

(2) *Second-degree reduction*: reducing the ignorance which is part of the risk. It may appear on two levels:
   (a) reducing uncertainty concerning the probability of certain damage;
   (b) reducing ignorance concerning the nature and scale of possible damage.

Second-degree reduction is based on the classical model of evaluating risk, where risk is the probability of certain damage: R (risk) $= P$ (probability) $\times S$ (damage scale). Reducing ignorance consists of hiding the ignorance of one or two sides of the equation: the probability of damage (P) or its scale (S).

As a result of first-degree reduction, the consequences of introducing a controversial technology are reduced to physical and biological phenomena. It is now possible to reduce a complex technological conflict to a debate over the harmfulness of any technology – a debate that can be solved by experts. Reducing conflict complexity consists of refusing to acknowledge any issue that does not concern physical risks or harmfulness and risk in general. One of the most important among the excluded issues is the innovative nature of a technology (in a broad, technical and social perspective).

Second-degree reduction, performed after the conflict has been reduced to a debate over risk, excludes the risk itself from the definition of reality. It follows a zero–one logic: the risk is presented using the opposites "harmful"–"harmless". When ignorance of the probability of damage (P) and/or of its scale (S) is reduced to zero, it can be 100% sure that the phenomenon in question is harmless. On the other hand, reducing ignorance by transforming the probability of damage into the certainty of damage ($P = 1$) and assuming a proper damage scale leads to defining the phenomenon as clearly harmful. This procedure allows ignorance to be reduced, which was an obstacle in risk assessment. At the same time, though, the very notion of "risk" is eliminated and reduced to "safety" or "danger". As risk always involves at least some quantum of ignorance, eliminating risk leads to reducing conflict complexity through minimizing ignorance.

As a result of reducing the complexity of the conflict, certain aspects of the technology in question are simply excluded, which leads to constructing ignorance. If a conflicting party manages to validate its definition of reality based on a reduced image of the conflict, then the elements which were excluded from the conflict discourse (and definitions of reality based on these elements) are shifted into what Bourdieu calls "social unconsciousness" and expand the domain of social ignorance.

Defining strategies

Reducing conflict complexity may be performed using one of three defining strategies: the strategy of declared safety, the strategy of declared harm and the precaution strategy. Each of these strategies is intended to help a conflicting party validate its definition of reality and thus redefine the conflict in a way that suits its needs. The winning strategy will determine not only the final definition of a controversial phenomenon in the public discourse, but also the very nature of the conflict and the way it is solved.

The strategy of declared safety and the strategy of declared harm perform first-degree reduction in a similar way and reduce the conflict to physical risk. This way, all arguments not concerning the physical harmfulness of the technology in question are simply considered invalid. What is excluded is usually the game of interests connected with the technology as well as the structural changes which might be caused by its implementation. Excluding the game of interests makes it possible to consider that the definitions of risk presented by conflicting parties reflect (more or less) objective reality and do not depend on non-scientific factors. In other words, excluding the game of interests implies hiding the social character of scientific knowledge. However, ignoring the conflict of interests is not only connected with defining, but concerns structural consequences as well. Not talking about possible interests which might be supported or impaired by a specific technological decision may have structural effects. Presenting the cultivation of GMOs as a purely ecological problem, for example, without taking into consideration the political and economic context (both local and international) leads to ignoring the major impact this technology has on agricultural production structure and on the balance of power in society (cf. Seifert 2005).

Apart from reducing the conflict to physical risk, the strategy of declared safety aims at redefining the technology as safe, using certain techniques of second-degree reduction (reducing ignorance). The objective here is to validate a definition of reality which considers the technology to be safe and, therefore, risk-free. In contrast, the aim of the declared harm strategy is to redefine technological conflict as an economic conflict. The conflict is presented as a market game with its specific rules concerning consumer choice, freedom of market competition, calculating profits and losses, economic progress, etc. As risk has been excluded from the discourse, any debate over the possible harmfulness of the technology seems pointless. Profitability becomes the main criterion in making technological decisions. A technology is presented in the guise of products entering the market and whose fate should be determined by consumers. A classic example of an economic conflict is the competition between technological solutions, each vying to set global standards, e.g. the competition between Blu-Ray and HD DVD systems or the historical debate over VHS, Betamax and video 2000. The competition between Windows and Linux systems also follows the logic of an economic conflict. A conflict on the market does not really involve any regulative state institutions, whose only function is to ensure freedom of competition.

The strategy of declared harm goes the opposite direction. Once the conflict has been reduced to the level of physical risk, the technology in question is defined as clearly harmful, i.e. having inevitable and disastrous ecological consequences. This way, the conflict is redefined and becomes an ecological one. It is now a conflict reduced to physical risk, concentrating mainly on possible hazards for human life and health and nature. No non-technical arguments are taken into consideration. The criterion which is supposed to clarify the controversies and solve the conflict is the physical–biological harmfulness of the technology. Some examples of this type of defining strategy include the debates over locating waste disposals, power plants or factories polluting the environment, disputes over the mobile phone industry and building telephone masts or over the harmfulness of certain medicines.

The third strategy is the precaution strategy, based on the precautionary principle. It states that, if there is any doubt as to the possible harmfulness or upheaval caused by the technology, we must continue to undertake actions aiming at preventing the destruction of the natural environment, regardless of the cost and of the fact that the harmfulness is not yet a substantiated scientific fact (Levidow and Murphy 2003, p. 54). The precautionary principle is a direct answer to the risks connected to technological innovations which have not yet been properly investigated. It is, therefore, a result of acknowledging our ignorance while introducing a new technology. Unlike the strategy of declared safety or declared harm, the precautionary strategy does not reduce ignorance, but makes it a starting point. The solution presented within this strategy is to refrain from using the technology in question until we obtain precise scientific data concerning its harmfulness or harmlessness. Ignorance is not considered to be an immanent feature of modern technologies, but a transitory state which can be overcome with scientific progress. By referring to scientific judgement, the precautionary strategy performs a first-degree reduction, reducing social risk to physical risk (as scientific investigation can only relate to what is physical). It leads to redefining technological conflict as a scientific conflict, which can be characterized as a conflict taking place within the domain of science and solved according to validation strategies typical of science. The precautionary strategy shifts the controversial issue into the domain of scientific judgement, removing the crux of the conflict from public discourse. As all measures concerning the use of the technology are suspended, the technological conflict is suspended as well, temporarily, until science provides a solution.

Techniques and ways of reducing conflict complexity

This section will present the most important techniques and ways of reducing conflict complexity used within each defining strategy. They will all be treated together, as most of them are applicable for all three strategies.

Risk naturalization

As has been stated earlier, the basic strategy of reducing conflict complexity is to reduce it to physical risk. This operation, which can be called naturalization, is part of the risk-assessment process.

One of the first steps in risk assessment is the delineation of the area of occurrence of potential risk. In practice, risk is usually evaluated by representatives of the mathematical and natural sciences and within the frameworks of these sciences and therefore risk is usually reduced to the biological/physical dimension: possible harmfulness to the environment and human health is assessed, but the social, political and economic consequences of the implementation of a specific technology are not (cf. Seifert 2005). As Beck (1992, p. 24) wrote:

> The debate on pollutant and toxic elements in air, water and foodstuffs, as well as on the destruction of nature and the environment in general, is still being conducted exclusively or dominantly in the terms and formulas of *natural* science. It remains unrecognized that a social, cultural and political meaning is inherent in such scientific "immiseration formulas".

A similar idea can be found in Nelkin's work (1995, p. 453):

> Quality of life issues are discussed in terms of the physical requirements for a disputed facility or the accuracy of risk calculations rather than the needs or concerns of a community. Concerns about the morality of foetal research are reduced to debates about the precise point which life begins.

Franz Seifert (2005) shows how the "hegemony" of physical risk has shaped the debate on the acceptability of producing genetically modified plants and this in turn has influenced the course of the conflict between the United States and the European Union on the World Trade Organization Panel. According to Seifert, physical risk "becomes decisive in any kind of restrictive regulation, at national, supranational or international level . . . As a consequence of physical risk hegemony scientific debates become the crucial conflict arenas" (*ibid*., p. 367). Levidow *et al*. express a similar idea, stating that the conflict over GMO's results from the fact that the EU regulation policy concentrates on physical risk: "EU policy has defined agribiotechnology as an expert scientific issue, involving precaution, though kept separate from socio-ethical issues" (Levidow *et al*. 2005, p. 266). It contributes to the growing distrust and unease of some parts of society, and, as a result, escalates the conflict.

Methodological rigor

Another mechanism connected to scientific practice is used for reducing uncertainty, which is part of second-degree reduction. The mechanism consists of expecting that science will provide clear evidence of the harmfulness or harmlessness of a technology or its products. Thus, we face the problem of interpreting the results of scientific research, which is very often incapable of clearly determining whether the technology is harmful or safe and can do nothing but merely indicate the possibility of safety or damage. Scientific results can therefore be interpreted as insufficient, inexact, uncertain and therefore unable to confirm the harmfulness of a technology (which is the strategy of declared safety). Expecting that scientific research will provide clear evidence of harmfulness may lead to questioning any non-100% evidence and to claiming that, due to insufficient proof, the technology can be considered harmless.

On the other hand, the lack of evidence of harmfulness can be interpreted within the strategy of declared harm in quite a different way, according to the principle claiming that "lack of proof of harmfulness is not a proof of harmlessness". This is why conflicting parties following the strategy of declared harm demand scientific proof of harmlessness. However, the methodology of science clearly states that there is no such thing as a proof of harmlessness. Science may not observe any possible hazards, but it cannot prove their non-existence (or, for that matter, the non-existence of anything).

The strategy of precaution proposes quite a different solution to this problem. Instead of being reduced, ignorance is accepted and made a starting point. The precautionary strategy assumes, however, that sooner or later science will be able to overcome its limitations and provide sufficient knowledge for making proper decisions concerning the technology in question.

Defining the acceptable level of risk

In order to determine whether something is harmful, the critical level which cannot be exceeded must first be defined, otherwise the influence of a technology (e.g. the consequences of using a certain chemical substance or electromagnetic radiation) can no longer be perceived as harmless. On the other hand, it also means that the critical level of acceptable risk must be determined. It is being determined not only based on scientific criteria, but also on the way people judge the phenomenon in question. In other words, defining the critical level of acceptable risk depends on the price that society is willing to pay to ensure the level of safety desired. How can determining the acceptable level of risk contribute to the symbolic reduction of risk? According to our hypothesis, if the risk level is sanctioned, society tends to treat anything below that level as harmless, and anything above it as harmful. As a result, we would be dealing with the social construction of safety and danger described above, which excludes and reduces uncertainty (and also risk).

Let us look more closely into the elements of the process of determining the acceptable risk level. This practice has been so fiercely criticized in risk theory (cf. e.g., Beck 1988, 1992; Wolf 1991; Scheer 1987; Conrad 1987) that here only the most important factors will be listed, contributing to the situation where risk gets reduced.

According to Scheer (1987), the very idea that "thresholds" can be established below which a substance is harmless and above which it suddenly becomes harmful was borrowed from radiation research. In this case it has actually been confirmed that radiation in excess of a specific limit will destroy protein particles and have toxic effects on living organisms. Thresholds marking the point of qualitative change are not universal, however. The relation between substance dose and its effect on the organism is often not linear. Yet it has become accepted practice to set threshold values for many substances, just as is done for radiation (Scheer 1987, p. 447).

Ignoring the process of accumulation of various substances is the next way of symbolically neutralizing risk. Acceptable levels are defined for one factor only. Nevertheless, substances are deposited in the human or animal organism and their effects accumulate. Add to this the practice of a single exposure to a large dose and a single measurement of its effects instead of long-term exposure to small doses, often a much better model of what actually happens in real life (Wolf 1991, p. 396). Other things that have been subject to criticism are reliance on animal studies and transference of their findings to humans and the brevity of the studies, which makes it impossible to identify all the effects of a substance. The latter is often forced on researchers by the logic of patent-based market competition, which puts a premium on original substance discoverers only. Industry tries to shorten the interval between discovery and introduction to the market as far as possible.

Risk assessment is also often unable to take the delayed consequences of many technologies into account. Some of the adverse effects of nuclear radiation following the bombing of Hiroshima and Nagasaki were not apparent until the 1960s (Scheer 1987, p. 449). This delayed effect is one of the reasons why some pharmaceuticals are withdrawn from the market despite previously being approved. Their adverse effects sometimes do not show up until the next generation (cf. Wehling 2004, pp. 79–82). Indeed, some dangers are completely overlooked in risk evaluations because the number of known cases of adverse effects is too small. This could be the case, for example, with certain diseases which may be caused by *in vitro* fertilization (cf. Schuh 2004).

The conflict of interests

Weingart (2005) wrote that the changing status of science as an institution is one of the constitutive features of contemporary societies (information societies, knowledge societies). He thinks that we are witnessing the increasing overlapping or mutual dependency of science, on the one hand, and politics, the economy and the media, on the other. This is leading to the development of new phenomena and processes at the science–politics–economy–media interface which affect the way things are done. Risk reduction is one of these new phenomena.

One of the major determinants of the risk-reducing process is the overlapping of science and big business. Science, both pure and applied, is increasingly becoming privatized or dominated by private enterprises. Obviously, private economic agents who reap profits from new technologies are loathe to advertise their inherent risks. This leads to conflict and tensions between businessmen, public regulative institutions and public opinion. Scientists are the intermediaries in these conflicts. Unfortunately, they are not always neutral, although that is what is expected of them. Sheldon Krimsky gives many examples of the large-scale conflict of interest at the science–business–politics interface in his book *Science in the private interest* (2003). Krimsky draws attention to the role played by advisory committees appointed by governmental agencies. In the North American legal system they have considerable influence on legislation and decision-making processes. Naturally, they should be objective, detached and, above all, not personally involved in the issues on which they pass opinions. They should also be extremely highly qualified. In practice, however – Krimsky argues – these demands are often difficult to reconcile because highly-qualified scientists usually also work for industry. A conflict of interest is thus very common among governmental experts and advisors.

Risk channeling and appropriation

Risk is channeled, i.e. it is reduced to a selected fragment which can be submitted to political and/or economic, preferably monopolistic, control. This method diverts attention from other threats and creates the impression that the risk in question is under control. The so-called international emission trade, advertised as a way to contain global warming, may serve as an example. In this method, economic advantage is taken of a technological controversy so that ongoing technological progress can be left relatively intact while economic profit is gleaned from the situation. At the same time, public opinion is given the signal that the situation is under control and so is the risk, as attested to by data on the development of the emission trade.

A good illustration of this mechanism can be found in the famous analysis conducted by the French sociologist, Philippe Roqueplo, who became interested in the debate on forest death in Germany and its relation to the introduction of the obligatory provision of cars with catalysers which took place in the early 1980s (Roqueplo 1986). Roqueplo demonstrated that, thanks to the way the political debate in the European Union was channeled, Germany managed to assert a beneficial interpretation of the reasons for forest death and gain economic advantage. Only private cars were "stigmatized" and other possible causes, such as SO_2 emissions caused by industry, electric power plants and trucks and lorries, were rejected. By channeling the problem this way, Germany, the world's leading producer of catalysers, could take advantage of the obligation to install them in cars.[4]

Withholding information about risk

The next type of method adopted to make risk invisible is withholding information in the strict sense. This is an example of conscious and deliberate action whose purpose is to prevent information about the dangers of a particular technology from leaking out. As Dorothy Nelkin states: "Secrecy can be a way to divert criticism, reduce the intrusion of burdensome regulations, prevent panic, and avoid costly delays" (Nelkin 1995, p. 455). She refers to the situation when, after the Chernobyl accident, federal agencies in the United Stated prohibited the energy agencies officials and thousands of scientists working in state laboratories to comment on the occurrence. "They feared that disclosure of information to the press would result in hasty and inappropriate public responses to the controversial American nuclear power program" (Nelkin 1995, p. 455).

Another good illustration is the court battle waged in 2004–2006 between Greenpeace, the French group CRIIGEN (Committee for Independent Research and Genetic Engineering) and the Monsanto biotechnological concern. The latter organization refused to disclose the results of research which was the basis for applying for permission to import MON863, a genetically modified species of maize produced by this concern. Everything began when a group of *Le Monde* journalists managed to gain access to data demonstrating that rats fed with this maize, which contained a toxic insecticide, developed severe blood and organ anomalies. The German branch of Greenpeace demanded that the concern reveal its research findings, but Monsanto refused on the grounds of commercial confidentiality. Yet, in 2005 the German court adjudged that the data had to be disclosed (Greenpeace 2007).

Apparently, such practices are frequent when publishing data on verified risk might threaten the actor's economic interests. Another striking example is the history of the DuPont concern. In 2005, the Environmental Protection Agency accused DuPont of withholding information on the risk of using perfluorooctane acid (popularly called Teflon) for over 20 years. The company agreed to pay a $10 million fine and allocate over $6 million to environmental protection programs. This was the largest administrative fine the EPA had ever adjudged. That same year, *Business week* magazine named DuPont No. 1 of "the Top Green Companies" (DuPont, Wikipedia).

Discourse and risk exclusion

Another area in which risk is made invisible is discourse. In their book *Lost reality. On the social construction of ignorance* (2005, pp. 69–84), Radosław Sojak and Daniel Wicenty write that knowledge may be both an instrument and an object of exclusion. This is why risk marginalization or exclusion from legitimate discourse plays a crucial role in the process of conflict reduction and the number of mechanisms operating in this area is so large that a discussion of them would exceed the scope of this article. Hence, only the most important ones will be highlighted.

It is suggested to look at the problem of reducing risk in discourse through the perspective of three "exclusion procedures" presented in Michel Foucault's *Discourse on language* (1972). The first one is prohibition, based on the taboo (things we cannot talk about), the ritual (what can be said in which circumstances) and on the privileged position of certain speakers. It concerns both the content and the possible forms of discourse. The other procedure is the opposition of reason and madness, the rational and the irrational. In the case of technological conflicts we are dealing with the separation of the scientific from the non-scientific and with setting standards of methodological accuracy. In a broader perspective, this opposition will also concern non-scientific rationality and manifest itself in statements such as "you cannot act against progress" or "progress cannot be stopped". The third procedure presented by Foucault is the opposition of true and false, used as a rhetorical strategy and an instrument in fighting to control discourse (and define risk). In the context of technological conflicts, it is based on scientific discourse and can be used for the purposes of methodological rigour strategy.

Discourse framing

In her article "Biotechnology and the politics of truth" (2005) Sally Brookes analyzes biotechnology from the perspective of different discourse frameworks functioning within a given discourse formation. Discourse formation is understood as a historically-originated system of discourse institutions and practices which define the discourse rules; the situation within a specific fragment of the discourse formation states which cognitive perspectives, approaches and conceptualizations are acceptable and will give the ultimate meaning to specific statements and contents (Brookes 2005, p. 363). In this perspective, the theory of discourse frameworks seems to be in accordance with Foucault's exclusion procedure based on the opposition of reason and madness. Setting a particular discourse framework depends on the commonly accepted criteria of determining what is reasonable and what is insane. Specific frames and practices are responsible for content inclusion/exclusion and framing. These frames integrate facts, theories, values and interests into cohesive structures. They say which discourse assumptions will be accepted as obvious and unquestionable. Brookes analyzes the frames of the discourse on the application of biotechnology in agriculture and points out their consequences for the legitimization of the GM food-based "green revolution".

As far as risk reduction is concerned, two frames are most crucial: the frame based on the assumption that "technology has its own trajectory" (*ibid*., p. 363) and the assumption that "biotechnology is natural" (*ibid*., p. 365). The first of these two assumptions views scientific and technological development as something inadvertent which progresses according to its own intrinsic logic and also as a politically neutral phenomenon offering more advantages than disadvantages. This frame ignores the aforementioned contemporary links between science, politics, the economy and the media. Possible adverse effects of technological development are excluded from this frame by relegating them (as "unscientific") to the realm of political practice. The second frame, which declares biotechnological neutrality, habituates public opinion to the futuristic associations evoked by bioengineering by stressing that it is "really" simply a continuation of earlier technologies ("people have always manipulated genes, e.g., by crossing animals or plants in order to obtain adequate varieties").

Maarten Hajer uses the concept of emblems to analyze ecological discourse. Emblems serve as metaphors helping to orient cognition and frame the problem (Hajer 1995, pp. 19–21; cf. Lakoff and Johnson 1980). They symbolize the problem, attract most public opinion and concentrate discourse on themselves. Hajer gives examples of global warming and the ozone hole (the 1980s) which replaced the earlier nuclear power emblem (the 1970s) or the pesticide problem (the 1960s), the mainstays of ecological discourse in each consecutive period (Hajer 1995, p. 20). It seems, therefore, that the emblem concept may be viewed as an attempt to specify the theory of discourse frames: emblems function within discourse frames according to a given discourse formation's superordinate rules of discourse. By concentrating the main body of discourse on itself, it helps to divert attention from other issues. Hence the peculiar struggle to make a problem into an emblem, as attested to by the year-long attempts to draw more attention to the problem of global warming.

Excluding people and information

The next technique of reducing risk through discourse also refers to Foucault's theory of "prohibition". This time the issue is not allowing certain speakers to take part in the discourse. Radosław Sojak and Daniel Wicenty think that the exclusion of people who proclaim certain information is a way of excluding information from discourse (Sojak and Wicenty 2005, pp. 69–84). "Exclusion of a person often leads to exclusion of certain information and the perspective on which it is founded" (*ibid*., 78). The exclusion of people and information is based on the rule that "those whose values and norms have been defined as bad have no right to participate in the game which constructs social reality" (*ibid*., p. 76). Sojak and Wicenty have analyzed many works on social studies of science and the history of scientific controversies in search of examples of such exclusion mechanisms (cf. also Barnes *et al*., 1996; Collins and Pinch, 1998). However, examples of this method can also be found in the technology discourse. Two examples from the Polish press are Zbigniew Wojtasinski's article under the telling title "The mad ecologist disease" (2003) and Wlodzimierz Zagórski's article "The new food magic" (2006), beginning with the words: "The opponents of genetically modified food are a new tribe of savages who believe in magic rather than science". If someone is declared a savage in the very first sentence, then how can he or she be taken seriously? As Sojak and Wicenty say: "to control knowledge is to control people. The use of such control excludes people and their knowledge from the community's interpretative interplay and the process of creating social reality" (Sojak and Wicenty 2005, p. 79).

The false symmetry strategy

Another discourse strategy for the marginalization and trivialization of risk is to emphasize the controversial and equivocal nature of a problem. The debate on global warming is an example of this strategy. This mechanism is particularly evident in the United States, where global warming is a major political issue, on both the international (the Kyoto Protocol) and the domestic planes (Al Gore's campaign or Arnold Schwarzenegger's "conversion" to ecologism). No wonder, therefore, that the belief that global warming has yet to be explained and that the effect of human activity on global climate change is still to be proven are upheld in public debate. One of the ways in which this is done is the media's practice of quoting voices for and against global warming in equal proportions. This way, under the guise of journalistic reliability and objectivity, the public is given the impression that scientists are divided in half on this issue. Things sometimes get even worse than this, e.g. when attempts are made to count the proponents and adversaries of each theory. This is what Gary S. Becker, winner of the Nobel Prize for Economics, for instance, wrote in an article appropriately entitled "Global hypocrites" (Becker 2007, p. 50):

> Humankind's responsibility for global warming is "very probable". That is what more than 2.5 thousand researchers, authors of the recent UN Intergovernmental Panel on Climate Change (IPCC) said. Not too few perhaps? At the same time 4 thousand other researchers signed the so-called Heidelberg Appeal protesting against the alleged connection between human activity and warming of the climate.

Sharon Begley argues that upholding controversy is a deliberate strategy adopted by PR specialists and conservative think-tanks connected to the oil industry (Begley 2007).

Rhetorical procedures

The discursive reduction of conflict complexity includes a number of rhetorical procedures, such as "discourse-closing categories", imputing ignorance, individualization, attachment, hierarchization and legalizing risk.

"*Discourse-closing categories*" are incantations whose use by one of the adversaries causes discourse to reach its limits. The aforementioned references to inadvertent or "no alternative" scientific progress, the accusation of critics of certain technological solutions of wishing to "return to the caves" or talk of the "necessary costs of progress", all belong to this discourse-closure category. The side-effect category also serves a similar function: this category was used for a long time to tame the hazards of technological development. As long as they were viewed as potential side effects, they could be marginalized and treated as "necessary evils".

Imputing ignorance involves excluding people and knowledge from discourse. It is based on the assumption that resistance to technological progress results from the lack of understanding of its true nature, i.e. from scientific ignorance. In other words, this method claims that every critical attitude towards a technology is caused by ignorance. As a logical conclusion, everyone who is against it is simply ignorant – if they were not ignorant, they would not be against it. Imputing ignorance is a method aiming at eliminating opponents by claiming that "they are mistaken, as they do not know what they are doing" and that they are being manipulated by ecologists or other demagogues.

Individualization involves reducing risk to the level of individual actions and decisions. It leads to ignoring the key aspect of modern risk: its non-individual (or even global, as Beck would say) character. Instead, risk is presented within the classical model of the personal risk undertaken by each individual responsible for his actions. Referring to the concept of the "responsible citizen" is, according to Beck, "nothing more than cynicism used by the institutions to make their failure look more beautiful" (Beck 2007, p. 107).

Hierarchization consists of creating a hierarchy of risks suiting the needs of every actor. In order to avoid a greater risk, it is possible to accept a lesser one. Introducing electronic monitoring systems in public places, for example, as well as implementing advanced citizen-control systems is supposed to prevent a greater risk of crime and terrorism. Producing nuclear energy is justified by the need to stop global warming.

Attachment involves making a connection between the technology in question and an important social problem it is intended to solve. The development of one of the more controversial fields of biotechnology, the so-called "green" biotechnology used in agriculture, is now being discussed together with the less controversial issues of "white" (industrial) and "red" (medical) biotechnology. It allows the GMO issue to be placed on the same level as the problem of combating hunger in the world, producing a cure for cancer or transplanting organs. The attachment procedure is strictly connected to the hierarchization method and refers to the classical way of calculating risk, which considers risks and opportunities. Using the attachment method is supposed to show that the risk in question is worth taking, as it will enable the prevention of greater threats or will have a positive social effect. It also refers to the value of progress by presenting the technology as groundbreaking and very innovative. As a result, considering the possible gains, blocking the implementation of the technology in question becomes irrational.

*Legalization***,** i.e. referring to the legal character of the technology in question, is a very common practice within the strategy of declared safety. It is based on the assumption that, once the technology has been subject to all necessary investigation and obtained a positive evaluation from the agencies and institutions created to assess risk, it must be harmless. This method involves ignoring any doubts concerning the effectiveness and reliability of risk-assessment procedures.

Conclusions

The reductive model of solving technological conflicts presented in this article is nothing but a theoretical construct, a tool for describing the dynamics of technological conflicts and attempting to understand them. Concentrating on the mechanisms of constructing ignorance (through conflict reduction), it highlights the problem of excluding certain aspects of technological progress from the public discourse, which is the result of the different strategies of defining used by the conflicting parties. Adopting this model allows us to analyze which elements are excluded, as each participant in the conflict formulates his own solution to the problem. However, it is also possible to imagine a non-reductive, normative model of solving technological conflicts which would prevent reduction and exclusion and make it possible to analyze the whole complexity and multi-level character of problems related to technological innovations.

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Notes

1. For a discussion of ignorance from a different research perspective, cf. Luhmann (1992), Merton (1987), Proctor (1995) and Sojak and Wicenty (2005).
2. This is why Wehling is reluctant to equate ignorance with risk. He thinks that risk, i.e. the probability that certain consequences will take place, is situated within the cognitive horizon of science because science must first identify these possible consequences; ignorance, meanwhile, also involves a lack of knowledge concerning the possible consequences of actions. Hence risk is scientifically-founded and, although it involves a considerable amount of uncertainty, this is not pure ignorance (Wehling 2004, pp. 70–71).
3. See *Public Library of Science (PLoS) neglected tropical diseases*, www.plosntds.org.
4. A similar case took place for many years in Poland due to Kazimierz Grabek, the monopolist in the production of gelatin, who successfully lobbied for bans on imports or higher customs duties on gelatin or its components under the pretext of the risk of mad cow disease.

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