1

Socially Responsible Research (SRR)

The implementation of scientific advances in our social practices without us being truly attentive to their impact on our values and representations, or at least with the feeling of powerlessness to control the inevitable process.

(Hirsch 2021)

I think we were so happy to develop all this criticism, because we were so sure of the authority of science. And that the authority of science would be shared because there was a common world. [...] We didn't even need to articulate this notion of a shared world, because it was self-evident. [...] Now we have people who no longer share the idea that there is a common world. And this changes everything, of course[1].

(Latour 2018)

The eternal question of disciplines and professions for which it is difficult to separate the context of discovery and the context of justification.

(Lénel 2014)

For a color version of all the figures in this chapter, see www.iste.co.uk/andre/knowledge2.zip.

1 Author's translation from the French version of the text.

1.1. Introduction

With the atomic bomb, after Oppenheimer, the academic world questioned the responsibility of researchers and engineers for technological innovations. It is always difficult to distinguish between right and wrong... but, for example, when we know that 24% of greenhouse gas emissions in the United States are directly linked to the industrial sector, it seems worthwhile to examine how science can help reduce this rate (Everett 2022). In elongating this need for responsibility, Grundwald (2014) points out that questions of technology assessment today extend as far as its future consequences and the need to take account of society's expectations. However, these expectations are subject to change, as can be seen today on certain issues associated with the war between Russia and Ukraine. It is becoming increasingly complex to distinguish between the individual and collective responsibilities of those involved in innovation. Debref et al. (2019) talk about inscribing social responsibility into the innovation process:

– taking into account potential impacts on social well-being (Pavie 2012);

– using social and environmental constraints to drive innovation (Temple et al. 2018). In other words, innovation has thus become responsible.

For Saint-Simon (1923), it is a question of "revising all ideas to base them on the principles of industry, to relate all morality to production", a morality centered on satisfying all the needs of the members of the social body. Today, disruptive innovations are taking hold, notably with digital technologies associated with the concept of Industry 4.0. They are changing concepts, knowledge, our way of living together and therefore our social practices as a whole. "Every technical object is a negotiation [...]; it is simultaneously the contract that momentarily seals the balance of power and the weapon brandished for other conflicts and negotiations" (Roqueplo 1983).

Even if the exercise is a delicate one, an ethics of the present day should explore new scientific fields and their possible consequences for society. It should go so far as to envisage modes of consultation with society, with a view to making the necessary trade-offs, albeit provisional and incomplete, choices (Hirsch 2021). Innovation is exploding in many fields to the point where attempts at exogenous anticipation, and even monitoring, are proving impossible. This is the current challenge facing ethical thinking. From now on, researchers and creative thinkers have a responsibility linked to their projects to produce new knowledge that can have an impact on society: pluralism of viewpoints and pluridisciplinarity of expertise with a view to the common good.

"Without the freedom to criticize technology, there is no 'technical progress' either, only and when this conditioning becomes cybernetic, as is the case today with new technologies, the threat becomes considerable" (Virilio 2001). Virilio takes up the Kantian theme of the public use of reason, which must always remain free (Kant and Mendelsohn 2007). But with big science, and its successive transformations, the novelties enabled by scientific developments bring us new technological possibilities every day. According to Fukuyama (2002), "today there are too many commercial interests and too much handling of money for self-regulation to continue to function properly in the future". Similarly, researchers are guided in their choices by the possibilities of access to funding, directed by the authorities in major programs (ANR in France and Horizon Europe in Brussels).

So we need to discover new ways of paying attention (getting out of our ivory towers), sharing knowledge (between scientists and technologists, on the one hand, and with society on the other) and interdisciplinary expertise in increasingly complex and wide-ranging fields, mobilizing and affirmation of choices. "It's all about recognizing the interconnectedness and importance of situated knowledge, and not pitting sources of knowledge against each other and the knowledge sources of scientists" (Lénel 2014). This principle of socially responsible research should enable us to move away from an overly disciplinary and "sacralized" conception of science, specific to France. In these circumstances, for informed debates, according to Jaeger and Mispelblom-Beyer (2014), the following two conditions are necessary:

– to not regard non-ideologized disagreements as a waste of time, an obstacle to the emergence of a truth (at least provisional) that can simply be revealed by asserting arguments of authority;

– to avoid bypassing them with a "conciliationism" that avoids taking a position and leads to inaction (Charlot 1995).

NOTE.– Ethics and responsibility.

In principle, "research ethics" concerns the conditions of acceptability of research involving humans, society and animals. In this chapter, proposals will focus on the social impacts of innovation and little on human-related aspects, and even less on animal ethics (see, for example, Potter 1971; Richmond 2000; Pinsart 2009; Halioua 2017). Under these conditions, thinking does not consist of denying the existence of reality, of "facts", but in emphasizing the part of construction in the perception we have of them. More than the question of discipline, it is the question of the need to study action that emerges, as this is not the prerogative of any discipline, human sciences or so-called "hard" sciences. So, rather than talking about ethics, which could lead to confusion, we have chosen to talk about the principles of responsibility.

NOTE.– Acceptability.

The expression of a goal to better respond to user aspirations from the earliest stages of innovation, and not in the final phase, when work is limited to the social acceptability of the final product, corresponds, according to Chouteau et al. (2020), to the final exploration of the theme. But in both of these "considerations", the word acceptability, more or less social, has been used. By "contribting to a metaorphosis" in the way some people deal with this word in relation to society, the discourse on responsible innovation has generally avoided undergoing a thorough conceptual deconstruction (Thapa et al. 2019). However, the dictionary indicates that acceptability refers to a character of something that is more or less tolerable. It is a tricky concept to define, apart from the perception, founded or unfounded, of risks. Since the end of the 30 years post World War Two, in most Western countries, public protests have been voiced. The rise of these reactions associated with technologies appears to be a public thematization of risks, that is, the formation in the public sphere (in the Habermasian sense) of universalizing norms such as "environmental and health protection" (Lehoux et al. 2019).

Generally speaking, the French are clearly interested in new technologies (Bauer et al. 2021). But within this framework between the social body and the worlds of research and innovation, how do the players – all of the players – position themselves, and who is ultimately responsible for what?

The necessary relationship between science and society undoubtedly need to be reexplored periodically with a view to strengthening trust between all stakeholders. The malaise linked to the loss of trust in the "system" is reflected in a number of opinions; but is it possible to find the right words to express and operationalize this search for agreement between science, technology and society (Kerninon 2009)? Ronsavallon (2006) distinguishes several forms of democracy:

– involvement where citizens join forces to produce a "common world";

– expression, linked to the manifestation of collective feelings;

– intervention that aims for joint action to achieve a chosen result.

In these three forms of political activity, it is clear that the "involvement" component of innovation is not strictly covered (Lechevalier 2019). Forms of mistrust and loss of legitimacy of certain technologies emerge from this deficit. There are several reasons for this negative assessment:

– the lack of explanation of what is being promoted in technological terms;

– the absence of an overarching vision;

– the weakness of a common intellectual elaboration between public and experts;

– the development of a "social disarticulation" by not sufficiently associating technological advantages and risks for humans and the environment (Touraine 1988);

– abusive extension given to the notion of harm (degradation of the principle of "non-negligence" according to Ogien (2007)).

1.2. Setting the scene

> Our culture dictates that we must win: on the battlefield as well as in cut-throat economic and scientific competition... now that we've reached the extreme limits of performance, martial violence and economics, are we so sure that we must always win, even spiritually? (Serres 2007).

> Are innovations revolutionary? Are they based on originality, the surprising, the unexpected? On the contrary, most of them are very conventional. They're based on simple, predictable laws of evolution that nature itself knows how to put to good use. To innovate is to think outside the box (Dortier 2015).

> The greater the speed of operation, the slower the response to the unexpected event (Ellul 1988).

The company creates technology in relation to its own culture and its own traditions, and in a recursive manner, technology is an important element in social evolution, "as customs adapt to technical availability and constraints and this transformation is often unexpected" (Gaudin 2005). Thus, it is becoming increasingly clear that man-made objects are not neutral and can lead to forms of ethnocide through artifacts (Jaulin 1970, 1977) but science, technology and society must integrate human components into all of their psychological and social complexities, as well as their temporal evolutions (Barré 2020).

On this theme, Habermas (2002) writes:

> At first glance, moral theory and ethics seem to be preoccupied with the same question: 'What must I do?'; 'What must we do?'. Only 'ought' no longer has the same meaning when we ask ourselves about the rights and duties we impute to everyone reciprocally from the point of view of the first person plural, and when, concerned about our own lives, we adopt the point of view of the first person singular to ask ourselves what, all things considered, is better to do in the long run 'for me' or 'for us'.

Thus, the purpose of this chapter is to introduce the framework of responsibility that could/should inhabit the thinking of researchers and/or inventors, especially if we take Michel Serres' (2008) opinion on the relationship between technical innovation and society into account. He writes: "By separating nature and culture in this way, have we committed an error of judgment, resulting in a mortal crime against ourselves and the world, both inert and living?". Indeed, in attempting to answer this question, we must take into account the influence of the progress of scientific knowledge on the understanding that researchers/inventors have of themselves as people responsible for their actions, even future ones. This reflection on responsibility corresponds to a modest proposal for a commitment to scientific research, adapted to "techno-sapiens" (Lipovetsky and Serroy 2008), toward an "ethics of knowledge".

As Figure 1.1 shows, the TRL values of these ideas, if possible prior to the production of a POC, are quite low.

Although the focus is on making the outcomes of innovation processes more accountable and desirable, the technological and commercial natures of these processes are not questioned in this book (for more on this topic, see, for example, Berger-Douce 2015; von Schomberg and Blok 2021).

Responsible innovation refers, according to Lehoux et al. (2019), to "different types of socio-technical systems that can be described as 'responsible' because they share the objective of meeting societal challenges and are oriented towards a common good that recognizes that life in society depends on the good governance of a shared set of resources (material or not)" (Flahault 2013; Forsyth and Johnson 2014). It involves an ethical reflection on the merits of technological development in a given social framework (von Schomberg 2013; Stilgoe et al. 2013).

Figure 1.2 illustrates the main components of the Lehoux et al. (2019) model and summarizes the empirical categories derived from individual studies. In this model, the rather interdisciplinary cognitive-technological activity involves different categories of resources of various origins (materials, capital, technologies, practical or scientific knowledge, etc.). This activity proceeds by "creative DIY" (Gurca and Ravishankar 2016), mutual learning and experimentation (see POC). It requires a technological and ethical design flexibility to envisage a socially "acceptable" achievement. Even if this is not part of French culture, it could be fostered by a cultural context where failure is seen as a source of learning and where the innovator may have room to maneuver. This is all the more true in the early stages of POC (Wittrock et al. 2021).

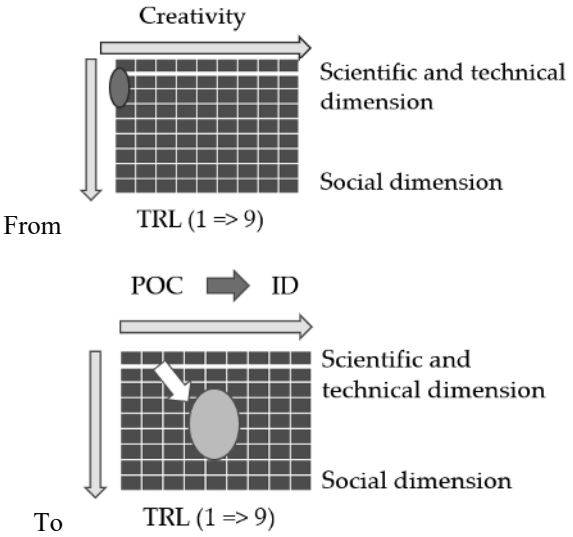

Figure 1.1. *TRL spaces for SRR*

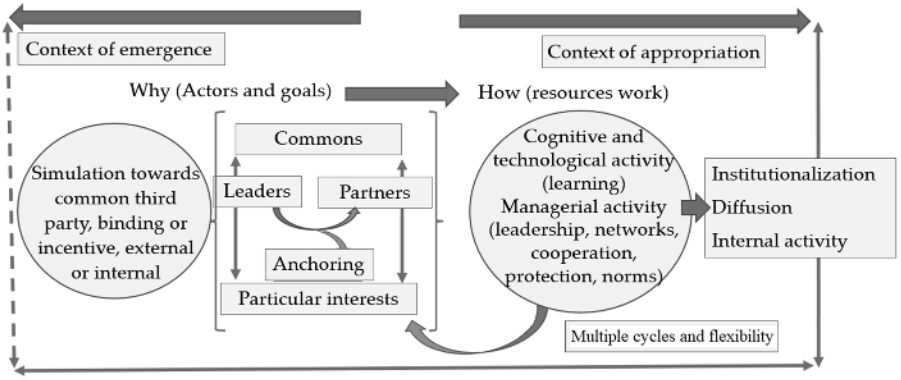

Figure 1.2. *Socially responsible research (SRR) between creation and society*

Without it being easy to notice, artifacts act through feedback on practices and culture of society to such an extent that de la Miranda (2010) has written: "By acting on matter, Man simultaneously acts on himself. This makes us not just external users, but theoretically responsible creators, insofar as technology is a part of ourselves". Within this framework, Attali (2007) assigns a number of missions to the world in the making. He writes:

> Freedom in the sense of less pain and effort, more free time, despite the eminently illusory nature of this freedom 'enclosed within four walls that are those of death and birth'. This freedom, the desire to live better within these four walls, the will to remove these walls by making life longer and better, and then the will to pass on better living conditions to those who will later live in this same room.

This ethic on how to "live well together", in the sense of Ricœur (1990) ("aiming for a good life, with and for others in just institutions"), leads sciences and/or creative people to help produce innumerable goods, elements of technological progress. In fact, today it seems that our technological know-how is increasingly outstripping man's knowledge, which is being disrupted by the very rapid dynamics of change. In any case, Puech (2008) writes that "technology is only neutral if it is considered as a means only, the difficulty being in the 'only'". Indeed, it cannot be considered neutral because of the instigation associated with the production of new consumer goods, and, as Ellul (1954) points out, because of the "principle of irreversibility of efficiency".

Feenberg (2004), drawing on cultural and ideological presuppositions, proposes that the approach to science-society implications, in relation to the technological adventure and its social significance, can be summed up in the following propositions:

– The technical design is not determined by a general criterion of efficiency, but by a social process that selects between technical alternatives according to a variety of case-specific criteria.

– The social process does not concern the satisfaction of "natural" human needs, but the cultural definition of these needs and therefore of the problems posed to technology.

– Competing definitions reflect conflicting social visions of modern society, embodied in different technical choices.

But what becomes of these proposals if we consider Saint-Exupéry's views on a form of soft totalitarianism? In 1943, he wrote of France and the United States:

> Today's man is held together, depending on the environment, with belote or bridge. We are surprisingly well castrated. So we are free at last. Our arms and legs were cut off, then we were left free to walk. Personally, I hate these times, when mankind is becoming gentle, polite and quiet cattle under 'universal totalitarianism'. We're led to believe that this is moral progress [...]. People who are fed ready-made food, standard food, like cattle being fed hay. That's the man of today (Saint-Exupéry 1956).

This aspect of social control is an essential part of SRR thinking and will be examined further below.

Heidegger (1958) wrote: “What kind of decision-making mechanism be put in place to enable all citizens to express their views, not on research itself, but on the questions raised by the applications of research?”. The rapprochement and integration between science and innovation leads us to reflect on the responsibility of the researcher or creative artist, in a context marked by an increasingly ambivalent acceptance of risk. While the researcher and the “applicator” are bound by forms of responsibility yet to be defined, the user is not always innocent of the use he makes of the devices he acquires. This is the case with the numerous detours of innovations that we have seen that had totally escaped the designers... In case of the exploration of uncontrolled fields in terms of risks to society and the environment associated with technological research, we need to explore new forms of social and cultural rationalization.

So, according to Neubauer and Joly (2004), there is a form of social control, the need for direct in scientific choices (see also Dietz 1995; Irwin 1995; Dienel and Renn 1997; Andersen and Jaeger 1999; Calame 1999; House of Lords 2000; Callon et al. 2001). The advantages of these practices can be summarized as follows:

– Participatory procedures can contribute to the political and objective legitimacy of decision-making processes. If we follow Callon’s (2003) definition of objectivity: “Knowledge can be said to be all the more objective when it has been put in a position to respond to the greatest possible number of objections”, then decisions taken with the participation of many different players have a better chance of being accepted by the public. The problem is to know how to share honestly between the knowledgeable and the uninitiated, and how to make the issues understandable to the public. Participation should, however, create a proximity between politicians and citizens that should reinforce the transparency of decision-making processes and encourage the reinstallation of trust.

– Citizen participation should improve the knowledge base on which decisions are made, as it includes the diversity of knowledge (local, empirical, traditional, and different worldviews) that is taken into account alongside expert knowledge (and which forces the “translation” of confined knowledge), enabling solutions to be found that are better adapted to the complex realities on the ground (Callon 2003; Neubauer and Joly 2004).

– The open science movement (Nosek et al. 2015) represents an effort to resolve the credibility crisis of coupling by promoting transparency in the research process (Tsui 2021).

– "Citizens' conferences or juries are places where new forms of knowledge creation are practiced. Unlike a poll or plebiscite, questions are open-ended and new ideas can enter the process".

– The use of expertise, in a very broad sense and across very different professions and sectors, ensures a multi-disciplinarity of viewpoints, values and different elements (scientific advice in politics was based on the idea of the independence of experts). However, this independence has become problematic, not least because of the commercialization of research.

– Deliberative procedures must avoid the predominance in decision-making of the particular of a single group of players. Experience proves the competence of laypersons in dealing with complex issues, and their ability to act in the general interest and from a long-term perspective.

– One of the aims of participatory procedures is also to enlighten citizens (without actually sharing the "deficit model") and thus contribute to opinion-forming. However, this transfer of scientific knowledge should take into account the variability of "lay" audiences who need to form their own viewpoints (Allum et al. 2008; Schefeule et al. 2009; Jakobsen et al. 2019; Wittrock et al. 2021; Deserti et al. 2022). What is more, this plurality of viewpoints is hardly diminished by the media industries that would, according to Brumfield (2009), be at the origin of reliable sources of information adapted to citizens' needs.

– From an economic point of view, although sometimes expensive at the outset (carrying out a procedure), they have a very good benefit/cost quotient over the medium and long term, since they have the advantage of preventing potential conflicts, anticipating resistance upstream and making the necessary adjustments in good time.

– From a practical point of view, co-created knowledge is needed to envision multi-dimensional and multi-scale innovation dynamics, initiated and monitored to encourage the creation of economic value alongside solutions to different challenges. In these processes, it is necessary to "test the innovation" to guarantee accountability of the final product.

– Scientific skills and competencies required for innovation as an exploratory mode covering the central theoretical perspectives and fundamental concepts of responsible innovation, on the one hand, and empirical insights into how actors address dilemmas and related tensions in different contexts when innovating, on the other hand (Jakobsen et al. 2019).

Schwarz and Thompson (1990) define technological development as a dynamic, evolutionary process that associates technologies with patterns of organization, even disorganization, in conjunction with creative ideas, thus introducing a three-dimensional perspective to studies of responsible innovation (see also Fløys

and Jakobsen 2017; Sjøtun 2019). Figure 1.3 therefore takes into account the fact that emerging innovations are part of a more complex discursive process, insofar as they are likely to produce a dynamic shift in "rationalities".

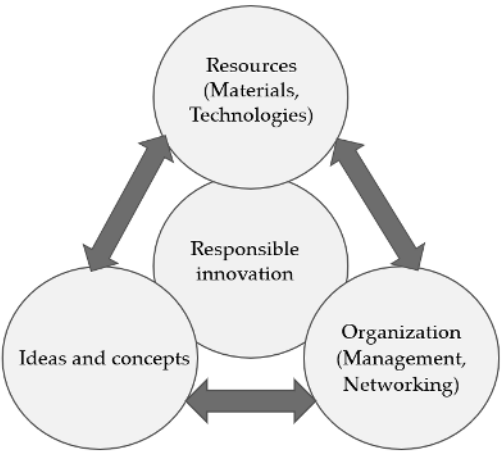

Figure 1.3. *For a responsible innovation*

1.2.1. *Decision-making and ethics*

Compartmentalizing disciplines leads either to literary people who don't know anything about science, who are ignorantly cultured, or to scientists who don't know anything about literature, who are uneducated and uncultured, i.e. two varieties of imbeciles. The problems we face today require all disciplines (Serres 2015).

The rejection by scientific thought of all ideas based upon value concepts, such as perfection, harmony, meaning and aim, and finally the complete devalorization of being, the separation of the world of value and the world of facts (Koyré 1968).

A society's organizing system co-evolves with its production system and defines how it understands the world and governs behavior, encompassing models of thought, belief systems, social systems, political systems, economic systems, and governance structures which impact ways of thinking, seeing and making decisions at individual, institutional and collective scales. The ultimate design of the production system will be indelibly based on choices and decisions

> relating to how we design the different elements of our organization system (Arbib et al. 2021).

Throughout this chapter, we will examine the difficulty of putting into operation the various aspects associated with the "socialization" of scientific activities, the researcher's "freedom", which makes them responsible in a democratic society because, for various reasons, they are obliged to make choices. In our Western democracies, individual freedom is less a right than a duty. The fact that it can be considered illusory in the name of all the determinations over which we have no control, and which guide our decisions, does nothing to change the imperative it indicates (Jurdant 1994). In another context, Comte-Sponville (2004) defines, in relation to decision-making processes, four interacting orders of potential interest to the world of technoscientific research:

– The techno-scientific order: we need to define the boundary between what is scientifically possible and what is impossible (this means that if only this order existed, as long as all of the funding was available, everything possible would normally be explored).

– The legal-political order corresponds to the democratic order and may differ from one country to another. The state manages constraints and interests to ensure the stability of the social body. In principle, there is no moral position on the part of the state in democratic systems.

– The moral order: this order subjects researchers to a certain number of moral requirements (if only because the knowledge of scientists, in the fields they dominate, is more important than that of citizens).

– The ethics order: framing actions with a view to the overall well-being of citizens (right/wrong relationships); this relationship to ethics depends on the society in which we live (evolving nature of perceptions, acceptability, attractiveness, context, etc.). It is an approach that aims to understand ourselves to know what is desirable or undesirable, good or bad.

The last two criteria focus on analyzing the moral justification for research into a new technology in processes of critical foresight, because the technologies in question are rarely value and impact free. In fact, being responsible means being able to make a decision in situations of uncertainty and, in particular, when it involves several orders at once, without confusing them. When they are in contradiction, responsibility is linked to the decision to give priority to one or the other. According to Simon (1947), the decision-making process is based on the representation of the "dissonant" situation in which we intend to intervene. It is conceivable, in line with Boudon (1977, 2009), that these more or less collective decisions will bring together different, even contradictory interests, but adapted to the situation (between a choice using "individual" decision theories or those of

games taking into account the effects of interdependencies and the "unpredictable" behavior of others).

This gives rise to forms of fragility that need to be addressed as scientific activity progresses. And this is precisely what the notion of socially responsible research expresses (André 2013). The European Union has introduced a number of "constraints", for example in the European Charter for Researchers (Horizon 2020 2020), which brings together elements of deontology and ethics research. In the 19th century, De Tocqueville (1981) wrote:

> Not far from this class is another party, whose object is to materialize mankind, to hit upon what is expedient without heeding what is just, to acquire knowledge without faith, and prosperity apart from virtue; assuming the title of the champions of modern civilization, and placing themselves in a station which they usurp with insolence, and from which they are driven by their own unworthiness.

Figure 1.4, taken from Tijdink et al. (2021), gives an idea of the scope covered by the SRR concept.

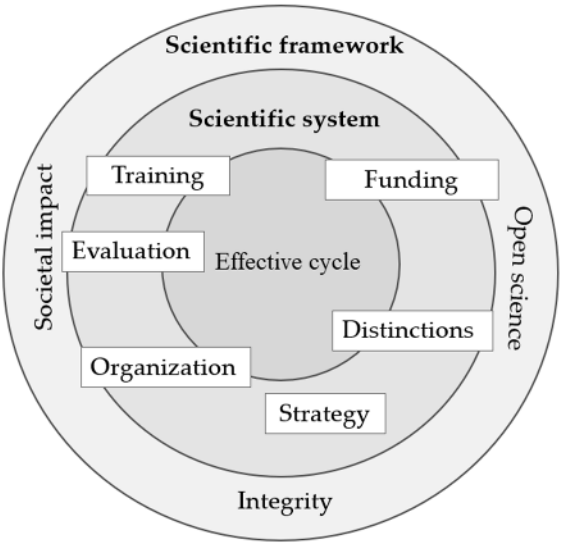

Figure 1.4. *Schematic representation of the elements that interact in responsible research practices; the three rings represent the different levels of consideration of SRR: scientific frameworks, the scientific system and the empirical cycle*

These authors have identified several main themes that need to be taken into account in future research in the field of social responsibility:

– evaluation responsible for research and researchers;

– the effect of open science and transparency on SRR;

– research on mentoring, supervision or responsible management and modeling managers;

– the effect of education and training on SRR;

– verification of reproducibility or robustness of results;

– mastering integrity challenges (Haven et al. 2019a, 2019b, 2021; Horbach and Halffman 2019);

– responsible evaluation.

NOTE.– Integrity.

Research practices that are, to say the least, imprecise from an ethical point of view, the research system with its high level of competition, unidimensional evaluation criteria, an individualistic research culture individualistic research culture and the pressure to publish for an academic career, can lead to unnecessary publications (Fanelli et al. 2015). Behaviors such as falsification, plagiarism and questionable research-checking practices are unacceptable (John et al. 2012; Haven et al. 2020). Research can result in misconduct, which can lead to rejection (Davies 2019) and risks of loss of confidence in science.

The situation is important for the creativity associated with artifact sciences, because "technological development transforms the meaning of what is human" (Heidegger 2003). Surprisingly, the framing of actions aimed at technological development is poorly developed in comparison with the life sciences, which are subject to a clear legal framework and recognized bioethical aspects (UNESCO 2005).

By way of example, Article 4 of the Universal Declaration on Bioethics and Human Rights (voted unanimously) imposes an imperative respect which illustrates this desire:

> In the application and advancement of scientific knowledge, medical practice and associated technologies, the direct and indirect benefits to patients, research participants and other affected individuals should be maximized, and any harmful effects likely to affect such individuals should be minimized.

Freud, in 1908, introduced elements now known as (Freud's) three frustrations: the first related to Galileo moving the center of the world; the second to Darwin

placing the ape as Man's cousin; and finally, to Freud himself placing human behavior in a new context. Should we add to these losses of egocentricity a fourth frustration for the researcher involved in the technological future, linked to a questioning of the premise of science? The questioning of his "freedom" or power?

The aim of this chapter is to show that the main role of science, which was to draw a coherent and acceptable picture of the world in which we are forced to live, is changing. Since, in particular, Isaac Newton, the world of intellectuals has been dominated by "natural laws", based on rational, scientific, mathematizable and, until recently, essentially deterministic thinking (André 2008). On these foundations, Weber (1985) considers that, in modernity as currently constructed, the rational, dominating context of technology translates into a control of social life that threatens non-technological values. This tendency leads to what he calls the "iron cage" of bureaucracy. He is joined on this point by Taylor (2001), who characterizes our techno-scientific civilization by the arrival of "moments of complexity" which are likely to lead, without us being careful, to very profound transformations in society (which he defines as a transformation of our cultural plausibilities). Similarly, Janicaud (2002) further underlines this when he writes: "The danger in talking about techno-scientific societies is to suggest that we are sacrificing ourselves to a kind of 'ontological majoration' of tech-noscience, i.e. that we are betting on its capacity to found a culture, civilization and humanity". Puech (2008), for his part, believes that "we are absorbed by the objects and their petty concerns. For this reason, we are deprived of the dignity of a way of thinking that asks questions about Being, which nonetheless constitutes a characteristic potential of the human being". This futility of things constitutes, according to this author, what Heidegger calls "dereliction" (see Heidegger 1927; quoted in Puech (2008)).

But it was the success of the scientific method that brought society to this high technological level:

> If the human condition consists in Man's being a conditioned being for whom everything, given or man-made, immediately becomes a condition of his further existence, then man 'adjusted' himself to an environment of machines the moment he designed them. [...] Even the most refined tool remains a servant, unable to guide or to replace the hand. Even the most primitive machine guides the body's labor and eventually replaces it altogether (Arendt 1968).

In fact, the line between acceptance and rejection of a technology depends on whether the technology is considered neutral, value-laden or simply symbolic:

> The invention of the steam engine and the locomotive is tantamount to the invention of a rail disaster [...] Each period of technical evolution brings with it its own set of instruments and machines, and the

> appearance of specific accidents, revealing 'in the negative' the rise of scientific thought (Virilio 1996).

There are two at least partly separate areas to explore: ethics and/or morals, on the one hand, and risks, on the other hand.

So, crisis after crisis, emotion after emotion, we must now ask ourselves what place the "arrogant intelligence" of scientific rationality should have when, for example, reserves are dwindling or when the social order is profoundly challenged by its technological contributions. Technological innovation results in new, previously unimagined possibilities, and makes certain tasks easier to perform (Reschler 1998). However, if we think about it, the overall effect is to make people's lives more subject to progress and more complicated. How far can we go to avoid going beyond the simple conservative tensions associated with technological progress? According to Nordon (2006), some scientists, particularly in theoretical disciplines, "consider that knowledge does not have to be useful, and work 'for the honor of the human spirit'". The thesis of the practical neutrality of science, reduced to mere knowledge, avoids the realm of action. Others, emerging from a set of fallacious representations of purely contemplative scientific knowledge (Lavelle 2007), want to be useful and proclaim that fundamental research is indispensable to applicable research (and vice versa)? For the latter, intention, decision, actions and their consequences fit perfectly into responsible action.

"Philosophers distinguish between knowledge and action, usually on the basis of Kant's critical division between the faculty of knowing and the faculty of desiring" (Lavelle 2007). And what many of them have in common is a desire to have it both ways: to work solely according to their own personal tastes, without taking orders from anyone else, and to derive additional glory from the fact that their work sometimes has positive applications. As Stengers and Bensaude-Vincent (2003) remind us:

> The contradiction between the admission of a strategic interest and the exaltation of disinterestedness is carefully avoided. Better still, any question raised about the legitimacy of such a disinterested pursuit is regarded as an act of criminalization – even a manifesto of anti-science.

This desire to be able to satisfy our own scientific desires is naturally also found in academic laboratories oriented toward engineering, as in all of the other sciences more specifically oriented toward the deepening of knowledge: "In many respects, society recognizes the importance of a search for knowledge […]. However, it is natural that there are more specific expectations on certain subjects and with a view to certain objectives" (Prieu et al. (2004); see also Forman

(2007)). However, lost in his solitude and in the multitude of disciplines, the researcher, in good faith, may never realize the influence he exerts. In 1819, Benjamin Constant, on this subject, but in a different context, wrote the following eloquent sentences: "Never did his will imprint itself on the whole: nothing establishes his cooperation in his own eyes […]. We have lost in imagination what we have gained in knowledge" (Constant 1997).

NOTE.– Interdisciplinarity, science and responsibility.

> How can we 'share' (in the etymological sense of the word communication) knowledge and build scientific knowledge off the beaten track? Our answer is twofold: by developing a dialogical ethic between indiscipline and responsibility, which is only possible by adopting an epistemology that breaks with the dream of a reason capable of saying what is true in an absolute and total way. In other words, drawing on the anarchist lessons of Kropotkin and Feyerabend, for whom it is the search for the researcher's emancipation that must govern the construction of scientific knowledge, and not confinement in some absolute and unsurpassable 'truth program' (Veyne 1983) – whether the latter is called 'discipline', 'pluri-discipline', 'inter-discipline' or even 'indiscipline'! (Dacheux 2013).

Classical science cannot think about its social and ecological responsibility because "for there to be responsibility, there must be a conscious subject; but the classical scientific vision (deterministic and reductionist) eliminates consciousness, eliminates the subject, eliminates freedom [...]". This "ethical blindness" of science is also due, continues the sociologist, to "the disciplinary culture, which fragments knowledge, and specialized training, which renders the scientist ignorant of, and then indifferent to, epistemological and, of course, ethical issues. Science is blind to what it is, what it is becoming, what it could or should be" (Morin 2004).

But under these conditions, society is increasingly calling to account those who have led it to its current state, unquestioningly dragged along by the media and advertising to the inevitable technical progress (to make themselves understood or to mask problems, such is the new "law" of communication (Mercier 2008))!

According to Tubiana (2007), "even the most rigorous scientists are afraid of upsetting the media by daring to tell the truth, because they feel that one day they will need them, so it is better keep quiet rather than oppose 'political correctness'". This situation of formal imbalance allows active groups (elements of temptation of democratic populism?) to unrelentingly raise the question of whether technology has indeed been developed to the measure of Man, in order to serve some purpose, or to less obvious objectives… However, "the social distribution of knowledge of

certain elements of daily reality can become highly complex and even confusing for the layman […]. In such a case, I seek not only the opinion of experts, but also and above all, the opinion of experts about experts" (Berger and Luckmann 2005). How, on such a basis, can trust reign? Thus, a loss of confidence develops in society, which, at the same time, demands novelty, which still allows us to affirm that if the scientific method and technology have conquered the world, it is because they tautologically correspond to positive and useful forces.

Technological evolution has a number of specific characteristics: it is irreversible, irresistible, discontinuous and uncontrolled. However, for a long time, the consequences of new technologies on society have only been considered as second-order consequences, since the effects are not related to the technology itself, and applications are at best the subject of general moral or ethical analyses. In reality, technological advances are essentially the object of at least apparently continuous processes, but they colonize our lives and insensibly change our habits and behavior (Ten Have 2007). This evolution does not normally give rise to ethical or moral questions, unless, through triggering mechanisms of various origins, they reveal the crossing of thresholds considered unacceptable. Minguet and Osty (2008) point out that:

> radical uncertainty refers to situations in which actors are unable to draw up reasoned anticipations of their actions, or to establish eventualities or probabilities concerning what might happen. They are faced with the impossibility of strategic calculation.

So this increasingly rapid transformation of the world translates a posteriori into tensions, constraints, unhappiness and profound cultural changes in society as a whole (Jacob 1997). This leads the social body, reinforced in its concerns by the power of the media, to look to science and technology for the causes of the malaise and to question those responsible to take a less specialized, more holistic stance (UNESCO 2000).

In this disintegrating landscape, is it possible, as Gonod (1990) puts it, "for society to master the development of the technology that is its creation and whose almost carcinogenic growth threatens its very existence, at the same time that it creates tremendous opportunities for humanity"? This chapter proposes the modest exploration of a "new" framework for scientific action which should make it possible, perhaps better, to redefine the role assigned to science and invention in our world in crisis. To achieve this minimum objective of pooling points of view, it is necessary to aim for bringing together science and technology, on the one hand, and social, cultural, political and economic realities, on the other hand, in order to achieve progress resulting from creativity and science, useful for society.

1.2.2. *Technological progress: the researcher and the risks*

> We are supposed to be trained for society and we are instructed as if each of us were to spend his life thinking alone in his cell, or dealing with indifferent people on trivial subjects (Rousseau 2009)[2].
>
> Interdisciplinary exchanges are not random. They can only be understood in terms of the subversive or legitimizing role they play in the host discipline. Thus, the chronology and modalities of transfer depend first and foremost on the conjuncture of the receiving milieu [...]. Like translation, the practice of interdisciplinarity is always a partial betrayal (Grenier and Lepetit 1989).
>
> Pluridisciplinarity, while it encourages confrontation and respects the pluralism of opinions and judgments, nevertheless remains within the strict disciplinary framework that was at the origin of the request. This is why the multidisciplinary approach, even if it provisionally replaces the compartmentalized disciplinary field with a communicational inter-field, runs the risk of resulting in a juxtaposition of points of view, with no overall coherence (Resweber 2000).

Prometheus, definitely unleashed, benefiting from the development of scientific knowledge and its achievements in terms of innovation, producing new things faster and faster, engages society as a whole in an indefinite process that leads to a plurality of unknown futures. These include those which presuppose the possibility of remaining within old, tried-and-tested paradigms, or, on the contrary, new areas for reflection and/or action based on foundations not yet taken into consideration (augmented man, new applications of genetics, sustainable development, global warming, reinforcement of the primacy of technology, intercultural and even inter-religious issues, etc.).

Having lived for millennia by following/subjecting time and the seasons – that's the whole agrarian period – mankind has almost succeeded in reversing the trend. Thanks to technology, it has even been possible to believe that neither time nor the seasons are any longer submissive, but increasingly controlled (alas, global warming is here to undermine this desire). Boissonnat (2007) reminds us that money is one of mankind's three great passions, along with sex and power. This change in temporal scale is associated with others: globalization, the apparent mastery of complexity through the fragmentation of production and, to a lesser extent, interdisciplinarity. Everything around us is on the move: the apparent, such as technology and its manifestations, but also the transition from work to employment, to precariousness

2 Author's translation from the French version of the text.

and the "obligation" to be free. The rules that lay bare the lives of so many people are a form of destructuring arbitrariness, usually far removed from the slightest democratic debate. As Durkheim (1963) already pointed out, "the republic is just when it ensures that contracts between individuals are truly free, that is, when it can certify that the contracting parties are placed in equivalent situations". However, the only thing that can be analyzed in this respect is the permanent movement that characterizes virtually all social structures. In this context, the problem of permanent movement has replaced that of simple change.

Technical innovations in all their forms are a silent revolution disrupting the state, the citizen, the employee, the hierarchical system within the company and the company itself, which is shifting from its role as vertical integrator to that of modular production, as a result of fragmentation... According to Janicaud (2002), technological progress is a dangerous utopia, because it provides ever-renewed material goods for the immediate satisfaction of "false" needs, whose long-term consequences are masked. To achieve this, companies are forced to develop their performance (from the individual to the global level) with a view of boosting their competitiveness, which is essential if they are to survive in today's value system, based on the only variable of instantaneous interest: very short-term financial profit, the foundation of capitalism. This context modifies the meaning given to the very notion of work and production, but at the same time shakes up rigid frameworks, inertial habits – in short, everyday life. It therefore creates disorder, sometimes creative, of desires associated with notable social progress, but also of risks, anxiety and a certain philosophy of resignation, because we have to adapt to technological evolutions that have not been co-constructed (Schumacher 1973a, 1973b; Puech 2008).

For Puech (2008), this situation is partly due to the fact that there is no real reappropriation of decisions by the public. He quotes Gandhi (1969): "I am absolutely convinced that no one loses his freedom except through his own weakness. However, this situation must take into account the fact that we live in a society with all the relations of explicit and, above all, implicit subjection that lead individuals to fit into 'socialization molds'" (Kaufmann 2001). This training (this molding) results in inertial forms of decision-making with the risk of cognitive due to cultural anchoring. According to Maalouf (1998), the context translates into the following reflections:

> Each of us has to make our way between the paths we are pushed into, and those we are forbidden to take or that are sown with pitfalls beneath our feet; we are not immediately ourselves, we are not content to 'become aware' of what we are; we become what we are.

At the same time, in line with Ulrich Beck (2003), we are moving from an industrial society for which the central objective was a certain form of wealth distribution to a society focused on another form of distribution, that is, of risk. On this basis, risk becomes a constitutive element of society. It is of a new nature, leading to a redefinition of social and political dynamics, based on a new, heterogeneous distribution of risk and the development of individualization. Under these conditions, according to Beck, "the recourse to scientific results for the socially binding definition of truth is becoming *more and more necessary,* but at the time same *less and less sufficient*".

Giddens (1994) takes a slightly different view, describing modernity as an ambivalent mix of comfort and anxiety, security and danger, and softening and hardening in the management of social conflict. He distinguishes three discontinuities between modern and traditional social institutions: the speed of change, the scope of change and the intrinsic nature of modern institutions. Others could be mentioned, such as the irreversibility of transformations... These elements, which it is not possible to go into here, place the business and society in what we call postmodernity or modernity pushed to its limits. Giddens (1994) writes on this subject:

> The desire to better control our environment through ever-greater knowledge of it constantly leads us to question knowledge and to act on our environment by modifying it. The point is not that there is no stable social world to know, but that knowledge of that world contributes to its unstable or mutable character[3].

Environmental research (in the broadest sense) explores this unprecedented change in context in a very indirect way. Mechanisms for dissociating time and space, such as the relocation of social systems and the reflexive (re)organization of social relations, contribute to the dynamism and excitement of modernity. They lead to a suspicious, uneasy reality.

However, dependent on the state or on social security systems, the institutes in charge of expertise on risks (their research is a means of maintaining internal competence and of exchange with the places where new knowledge is created) are confronted with maintaining trust between those who bear the risks and those who produce them based on success stories that make it possible to highlight effectively measurable improvements. This means that, essentially, the search for cause–effect relationships is, from the outset, a practically necessary condition for the success of the action by leading to credible rational prevention solutions, because they are understandable by all stakeholders. Thus, in the recent past in the prevention of

3 Author's translation from the French version of the text.

professional and environmental risks, the study of the harmful consequences, in terms of accidents or occupational diseases, has made it possible to seek the causes, and, consequently, to reduce the undesirable effects (values exposure limits, standardization, regulations, etc.). Philip (2007) has defined the principles that apply to sustainable development, but this context is flawed in many situations (time lag, multi-factoriality, multiple origins, irreversibilities, failure to take populations into account concerned, etc.).

These different elements illustrate the fact that knowledge and understanding chronic risks prevention, even accidents, are at the heart of our "world" only mediated by a social existence (a recognition): it is not the scientific knowledge itself which must modify the living conditions of citizens, taken in the broad sense, but knowledge taken in forms of appropriation and specific enhancements which come under social debate. Scientific uncertainty is therefore increasingly reflected in a kind of demand for a representation that conforms to our own perception (with all of the limits we know) (Libaert 2003).

The society of risk, as developed by Beck (2003) and more recently by Nowotny et al. (2003, 2005) and Gibbons et al. (1994), introduces the need to recontextualize scientific activity in the field of a society that is both better and worse informed, concerned about an uncertain future and marked by environmental issues (including those related to work). We thus talk about responding to "social demand"; however, this demand is rarely expressed, hence, in some documents, the concept of "latent" social demand, which cannot be "average". It would be better to speak of research issues that concern certain social groups, but, under these conditions, we would lose the whole "unifying" aspect of the concept of social demand, a real rhetorical leitmotiv today...

NOTE.– (Responsible) relationship with the public.

Table 1.1, taken from Tait (2017), illustrates the difficulties related to the relationship between science and society.

The precautionary principle, which has been incorporated into the Constitution in a context of complexity and scientific uncertainty (André 2005, 2006). However, social pressure and the use of experts outside the strict scope of their knowledge raise serious doubts about the robust use of science in expert appraisal, if only because the "teachers" may be the originators of what may be questionable (André and Masse 2002)! This can lead to a desire to control science by a public which, whether conditioned or not, is more inclined to focus on the negative and irrational side of the risk issue than on the possibility of an approach based on a medium- or even long-term dynamic of the "cost–benefit" or "interest-disadvantage" type.

Group thinking	The opinions of small groups can be influenced by participants with strong opinions or those who lead the engagement (so-called dress effect)
Framing of questions	Unengaged citizens do not want to participate in hypothetical discussions – recruitment risks being biased in favor of those with a scientific background
Recruitment bias	Unengaged citizens do not want to participate in hypothetical discussions – recruitment risks being biased in favor of those with a scientific background
Conflicts	Why would there be agreement on an issue related to disruptive technologies, especially if there is a polarization of opinion
Disorientation	Some vast and multidimensional subjects are too general to have an informed opinion upstream
Weariness	In order to judge you have to look more deeply, which requires time and resources, insufficient for engaging on each question
Changing opinions	People do not yet have a clear opinion and will change their minds in the relatively short-term (faster than the duration of a research study)

Table 1.1. *Difficult relationships between science and the public*

According to Morin (2000), this situation stems from the fact that "we teach certainties, but never fundamental uncertainty". But is this possible? Julliard (2008) points out, in this relatively new context, that "the democracy by default of the past is being replaced by the democracy by excess of the present, where the citizen's problem is not to be informed, but to resist information". Today, there is a plethora of information channels, from radio and television to the Internet, blogs, forums, newspapers and so on. According to this author, we are somewhere between an "opinion" and "opinionated opinion", illustrating the fact that public opinion is an artifact... This view is backed up by Sfez (1992), who considers that "consumers of communicational products are supposed to be enlightened, in all matters of opinion, even though opinion is 'preformed', powerless because technology has become our living environment".

This well-known observation of a "fuzzy" and labile opinion, as in the case of genetically modified organisms or "human augmentation", recalls the "doxocracy" dear to Bourdieu (1973) and leads to reflection on a so-called science mode 2, carried out in concert with society, in connection with the social dynamics at work (Nowotny 2003, 2005). According to Blondiaux (2008), "the idea of an inevitable strengthening of citizen participation in political decision-making is also gaining ground every day in most major Western democracies". The questioning of the delegates of representative democracy therefore strengthens the power of public opinion, sometimes that of the street, supported by those disappointed with the power in place, whatever it may be. These rather new conditions must – at least in

part – take researchers out of their discipline (Leydesdorff and Etzkowitz 2000), the "so-called" mode 2, which is an important political choice, would not be so new (see also Bensaude-Vincent (2009)). It is therefore a question of defining modes of action where science and society work together, avoiding, as far as possible, the unconsidered loss of confidence in the positive contributions of science. Mode 1, stemming from the end of the last world war, is an intellectual and lobbying construct aimed at justifying scientific autonomy (Bush 1980). For Foray (2001), this is an evolution where mode 1, which makes the assumption that scientists do not have strictly the same interests as society, would be subject to mode 2. As this subjection is still to be made (see also Zweiacker (2007)).

There must therefore be ways of "mobilizing" (but by whom?) this knowledge with a view to a form of social utility that must be perceived as such. Indeed, if we assume that it is possible to seriously anticipate a risk, and that reliable solutions are envisaged right from the design stage of an operation, the net result is that the risk will never be perceived! With significant heterogeneity in citizens' views of what is right and just, and with the unprecedented development of individualism (Bourg and Schlegel 2001), social demand is only present on situations deemed alarming by groups formed around this single problem, that is, when it is almost too late. Gauchet (2002) reminds us that:

> it's worth asking whether we're not witnessing one of the great oscillations that Western societies have periodically experienced since the 'invention of the individual'. Oscillations linked to the difficulty, if not the impossibility, of thinking together individual and society, to reconstruct society from individuals.

The demand for change is very largely based on real effects or impressions that affect individuals. As Gauchet (2002) puts it, the source of these problems lies in the fact that "distance and mistrust are the two sources of contemporary individualism".

Sloterdijk (2000), followed by Fleury (2002), introduces principles of disruption that force correction. Fleury writes: "To question the non-real (which is the accident) is to question the nature of the real that confronts us, whether its modality is visible [...] or invisible". Accidents, like pain, appear to be the privileged occasion for an encounter with truth. In any case, these disruptions induce a loss of confidence between science and society. It is on this basis that research is called for, with strong pressure to produce preventive solutions quickly: banning certain products, exposure limit values, collective and individual protective equipment, process changes, etc. It is a classic case of getting a (slightly) seized-up system up and running again, by greasing it up or fixing it! However, this means that the context is part of a rather acceptable rational dynamic thanks to the processes induced by the mono-disciplinary scientific approach. There is therefore no fundamental questioning of practices.

The principle of nonindependent research (involving at least a state-paid salary) necessarily implies forms of bi-univocal relationship between academic research and society. According to Julliard (2008), there are three instances of expression of the popular "will": democratic suffrage, opinion and the field or street... Until recently, it was the democratic elites, in conjunction with the power of scientists and companies, who promoted science to its current level. Various "affairs" have, at least in part, removed some of those who legitimately represented opinions to the benefit of players who are undoubtedly more militant. Recognition of the diminishing legitimacy of political representation is partially affirmed in the Lisbon Treaty on the European Union (2007) (quoted by Blondiaux (2008)), which encourages "an open, transparent and regular dialogue with representative associations and civil society" (article 8B).

However, this is no more than an observation: in certain situations, whether critical or rendered critical, the center of gravity of power has shifted from rationality to the immediacy of manifestation. Who, then, robustly represents today's opinion? Who can the scientist trust? In the previous period, as Bruner (2002) reminds us, "we might not unreasonably think that the science of statistics was invented to protect us from our great weakness in predicting. The fact remains that it is our hopes and desires that drive us". The stability of modes of thought and action in research is, to a large extent, linked to the existence of scientific disciplines (but how else can we do it!) and, no doubt for reasons of power, in the broadest sense, by the existence of plans: the Brussels Framework Programme for Research and Development, the European Research Area, and development framework programs, as well as the programs of major research organizations, ministries and funding agencies (ANR in France). These frameworks, which are far removed from new forms of opinion, are linked to the money made available through intentional incentives, and thus, for researchers, to the possibility of acting (more) serenely, at least for a time, in the areas funded...

Over time, this context leads to a strengthening of the mono-disciplinary culture and influences the societal fields in which states "invest" their best brains (or even those of others) (Hacking 2001). However, in the current scientific intellectual movement, whatever it may be, we can consider that the values of objectivity, coherence, rationality and justification are well respected (Berthelot et al. 2005). A number of elements need to be taken into account in these different areas:

– There is an "emergent" demand (we can assume that an anticipation work has been carried out?) which induces a more or less disciplinary parceling out of actions.

– This demand translates into a quest for performance for which, in the current time pressure to focus on an optimum number (i.e. the smallest possible number) of influencing parameters to improve/innovate for performance. As a result, lower priority elements, such as those corresponding to risks, are referred to other players,

to regulations, for lack of culture, time or even lack of interest or simple understanding.

Under these conditions, it seems difficult to envisage an easy integration of all of the components needed to take into account the concept of risk avoidance (some of which are not even imagined by those who may be behind them) in the quest for the fastest possible economic performance. What is more, for society as a whole, media analysis rarely raises the classic question of the relationship between capital and labor, between the production of attractive goods and potential risks of technical progress, the birth rate, "eternal youth", health, pensions, immigration and intercultural relations, and so on. Where is prevention if there is no effective social pressure, even "at the café du commerce"? It is in this context that ecology has a hard time getting its message across!

These considerations illustrate the wide gap between the desire to approach a society, which is irreversibly being built up on a global scale, and the atomization of the work of the researcher, who has little or no mastery of the organization for which they exercise their talents: they do not think of themselves among the others and in terms of the community. Generally speaking, they are unable to distance themselves from others and ensure that they are different or complementary. "It goes without saying that science is a historically situated social activity and must be understood in relation to the contexts in which it exists" (Shapin 1998). The result is a certain form of de facto formatting, or even "embrigadement" of scientific development (Thuillier 1971). In the field of science alone, this formatting is defined by Kuhn (1983) on the basis of a paradigm: "Universally recognized scientific discoveries which, for a time, provide a community of researchers with standard problems and solutions" (Kuhn 1983; see also Omnès 1994).

Thus,

> to speak of a paradigm is both to say that there is a social constraint to think in accordance with a major example of explanation, the one that passes for particularly luminous at the time, and, at the same time, that those who do not think in this way, or who are too concerned with what the preferred mode of explanation does not explain, are momentarily marginalized (Descombes 1989)!

In fact, science and society are underpinned by two phenomena (at least): complexity and interdependence, both of which can be addressed through interdisciplinarity. Complexity is synonymous with a multiplicity of possibilities. To act, we need to reduce this multiplicity. This is precisely what trust allows (in principle) (Quéré 2001). This trust, which presupposes agreement on the loyalty of all actors investing in uncertainty, is only partial, for a variety of reasons (André 2006). For example, the Canadian Food Inspection Agency (CFIA 2008) conducted

a study on the factors influencing public attitudes in the 21st century. The following elements are cited as:

– distrust of all institutions;

– dependence on advanced technologies;

– realization of the interconnectedness of actions and consequences – global scale;

– use and complexity of technology in human society;

– understanding the contribution of human choices and behavior in the face of danger;

– distrust of risk assessment.

At the same time, according to Coote and Franklin (1999), the public, in the eyes of political scientists:

– is unable to understand complex issues;

– is unable to form relevant points of view;

– believes everything they read in the papers;

– forms an opinion based on narrow, selfish concerns;

– is apathetic;

– does not want to take the time or make the effort to think (André 2006) about anything that does not directly affect them.

In short, all is well until the next crisis... Against this backdrop, Fischhoff (1998) presents the necessary elements of risk communication to the public in a presumably cynical manner. All we have to do is:

– get the numbers right;

– tell them the numbers;

– explain what we mean by the numbers;

– show them that they have accepted similar risks in the past;

– that it is a good deal for them;

– treat them nicely;

– make them partners;

– all of the above.

In principle, this general framework reaches the researcher who is not confronted with an interdisciplinary approach (on average, but there are always deviants). The aim of this mode of action is to translate "real-world" problems into scientifically possible interdisciplinary actions, based on a technoscientific evolution which, while often in continuity with previous activities, is not a prolongation of them (particularly in the associated social significance) (Gras 2003). While a large part of the industry has mastered these approaches for its own survival, and apart from the incantatory rhetoric of many principals, this desire to promote the idea that "the whole is greater than the sum of its parts" is being severely undermined:

– recognition by their peers difficult for scientists acting in an interdisciplinary;

– career problems (Vinck 1995);

– difficulty integrating the various disciplinary elements;

– how can we find out about the methods and practices of other disciplines that are necessary for action? How can we understand each other?;

– the "trial and error" approach implies knowledge of the dynamic of the various players involved, and does not fit in well with action programs;

– creation of new disciplines through mergers, bi-disciplinaries (e.g. biophysics, etc.) which restructure action within a new framework but using the same forms of "recognition" (adapted scientific journals, peers in the field, etc.);

– from an epistemological point of view, the creation of new knowledge does not follow a linear process. It is therefore difficult to synchronize knowledge from different disciplines.

In addition, the development of quantitative methods for evaluating researchers through so-called criteria, imposed by the massification of research and the immediacy of everything, results in a modest recognition of innovation, particularly if it is interdisciplinary in origin (see Chapter 1 of Volume 1). By attempting to reconcile the points of view between science and society, we are generally a long way off the mark... There is a risk of transferring responsibility for risk-related work to a few "scapegoats", because that is what they are supposed to do... So, if we are to make any headway in the field of risk, in a world of ever-increasing complexity, we need to think in terms of different modes of action. In this new adventure, made necessary, several operations must be attempted, relying on a plurality of players acting in a concerted manner:

– "visionaries" involved in forward-looking thinking, in contact with the world of innovation, research in the human and social sciences, etc. Their task is to define scenarios for debate with society;

– integrators responsible for taking into account, in anticipation, society's problems to be addressed through interdisciplinarity;

– the players, true project managers, have the difficult task of defining a methodology evolving through the use of experience feedback, and explaining to society how it is possible to "modestly" manage a certain form of complexity;

– disciplinary research players.

1.2.3. *Scapegoating*

> In a political, social and consumer vacuum, the formula for determining the likelihood of job replacement would be simple: if the technology available could match human behaviour and operate at a lower cost-per-production ratio, the job would be automated (UNESCO 2021).
>
> The 'trivialization of evil' is only effective because humanity as a whole sacralizes technology, and this sacralization takes place in a totally unconscious way (Decarsin 2021).
>
> The pandemic allows us to see how the health political, economic and technical systems cooperate to this end. To the detriment of freedom [...] and the global ecosystem, i.e. life, in an infantilism that prevents us from giving up our polluting recreational vehicles. Here's a totalitarianism we're increasingly powerless to resist because, since it's universal, it's also increasingly difficult for us to become aware of it and put up a resistance worthy of the name (Dufresne 2021).

For a long time, scientists were able to steer clear of crises associated linked to the emergence of risks considered unacceptable by society. Recently, however, society has begun to call to account those who may be at the root of new problems. In France, for example, the *Commission nationale du débat public* (French National Commission for Public Debate) is conducting debates on the useful effects and/or environmental and social impacts of nanotechnologies, or on the burial of nuclear waste (Métais et al. 2014).

Within this new framework, not only industrialists but also researchers from the public sector are invited to take part in the debate. Pro-foundational crises can probably be avoided by encouraging such debates between science, technology and society. The French government has wisely set up "professional" risk-management interface providers (INERIS, IRSN, INRS, etc.). The following pages reflect the author's vision of the role of these institutes in harmonizing the relationship between

scientific knowledge of risks and hazards, on the one hand, and social representations of these risks, on the other hand. The existence of disagreements between the various stakeholders (which do not yet concern the world of academic research) result in crises and losses of trust (Redlingshoefer et al. 2014). Recently, this is what we experienced with the Covid-19 crisis.

The crisis, for Heiderich (2007), results from the combination of an objective event and a set of individual perceptions which can lead, through the associated tensions, to a symbolic disconnection. There are generally what he calls "media iterations" produced in the moment and "contingent by retinal thought", which are associated with the demand for a conforming representation, more or less linked to a prioris and cultural references (Libaert 2003). Research actors are only rarely prepared for crisis management, nor knowledge of the fragility of the systems in which they work, which can be of particular concern for the maintenance of trust between their world and society. Thus,

> it is not only the relationship with the other, insofar as he is different from his origins, which signals the crisis, it is also the relationship with the other, insofar as he is similar. Similar, but in its individual singularity: like me, an autonomous individual, therefore different from me. Incivility is also practiced between equals (Bensaïd 1999).

In one of his books, Girard (1982) examines the various stereotypes of crises linked to misunderstandings between stakeholders and "associated persecutions": it is the juxtaposition of several stereotypes in a single document that leads to the conclusion of persecution. Not all stereotypes have to be present. Three of them are enough, and often even two. Their presence leads us to assert that:

> – the violence is real;
>
> – the crisis is real;
>
> – the victims are chosen not by virtue of the crimes attributed to them, but by virtue of their "victim" signs, anything that suggests their guilty affinity with the crisis;
>
> – the point of the operation is to shift the responsibility of this crisis and to act upon it by destroying said victims, or at least expelling them from the community they pollute.

For Girard, this model is universal, both when reading historical texts and on a planetary scale. If this myth is found in a stable way in time and in space, the French National Institute for Research and Security (*Institut national de recherché et de sécurité*, INRS), one of the components of the Social Security Prevention Institution, administered by the social partners, but financed by the state, was the object a few

years ago of a keen and critical gaze from the media, then from the state, associated with a form of "moralizing one-upmanship which seeks to flush out misguided goodwill or help bad at hiding" (Slama 1993). This institute of research and scientific expertise can be one of the examples of challenges by society and can serve as an element of reflection (for tomorrow?) for the world of research and expertise associated with a context of social utility…

What "crises" for the research and expertise center (which the author knew well) of the social insurer responsible for occupational risks! Asbestos, glycol ethers, possible links between genetics and work, the possible toxicity of aluminum, etc. Today, nanoparticles are emerging in a context where asbestos has rightly left "disastrous memories". How will the "ordinary" research community, committed to "sensitive" subjects and less trained in expertise, resist crises linked to risks in the future?

In this example, can we consider that there is a clear desire to harm the company in the workplace on the part of the social insurer? Or on the contrary, the emergence collective worries reflected in the persecution of the right "scapegoat", the right "target"(!)? This is a fundamental question that needs to be considered! Could this institute have broken a certain "harmony" that led to this desire to purge in the name of a false "social correctness"? Has there been too rapid a change in the social acceptability the nature of risk changed? These different elements focus the questioning on what represents acceptable (professional) risk in today's rapidly changing world, but also on why the emergence of media phenomena, true sacrificial preparation, ultimately seeking to make the victim alien to their basic mission? Based on the victim stereotypes presented by Girard (1982, 1973), we can show below that this institute has all the "assets" it needs to achieve a form of persecution aimed at opprobrium and elimination by militant actors.

1.2.3.1. *The reality of violence*

Both technical and organizational developments make it impossible to treat the world (including the world of work) as an idyll between employee and employer, or between citizen and state (see Gilets jaunes) because of the high human and social costs. Almost permanent technical and organizational change, precariousness, unemployment and globalization are all factors that increase citizens' uncertainty about the world of work, which also provides social status, meaning in life, etc. (Roman 1998). In this context, where there is (alas) no such thing as zero risk, there are operators who suffer from accidents or illness (the approximate cost is around 10 billion euros a year for France (paid by social insurance), but this probably does not take into account all of the factors associated with the occurrence of the accident or illness).

If employees are, on average, increasingly removed from risk areas in production workshops thanks to the automation of operations, we expect – as has been observed for several decades – a certain reduction in the number of work accidents. Today,

however, the hundreds of fatalities every year show that further progress still needs to be made, always with the aim of making work less dangerous. It has to be said that the economy is largely shifting from a production-based economy to one based on knowledge and associated services, systems for which the rules of operation have not yet been fully stabilized, but which result in fewer accidents.

However, at the same time, the number of occupational illnesses is on the rise, from musculoskeletal disorders to more serious, long-lasting occupational cancers. Against this backdrop, asbestos continues to focus the harmful effects of work on insufficiently informed and protected operators. Thus, violence is real, even if progress has been made and its effects continue to benefit the world of work. The same is true, albeit to a lesser extent (because it is not financed), for citizens suffering the effects of various forms of pollution, for example.

1.2.3.2. *Crisis reality*

Godard et al. (2002) illustrate the existence of organizational continuities in the *Traité des nouveaux risques*, particularly with regard to risk expertise and management. They write:

> Does the insistence on scientific risk assessment in the context of precautionary policies appear suspect [...]? It is said to perpetuate the scientistic myths of the preceding historical period, or to convey strategies aimed, under the pretext of rigor and objectivity, at evacuating legitimate social approaches.

By relegating those who are affected to the role of suffering victim and by reinforcing the primacy of scientific advice, we create tensions, even the emergence of crises. Audoin (1999) recalls that "our body has become our place of deployment. We maintain it because it is our intangible capital". Thus, because of the development of self-care and the appearances of what we want (or seem) to be, there is an evolution in the social acceptability of risk in the context of work (Demortain 1999) and therefore to be an effective partner in dealing with the problem. In this context, the taste for individual risk is offset by the aversion to imposed risk. Any information likely to associate a new risk with a possible effect on someone's body then translates into new anxiety, anxiety reinforced by the media which "fill with superficial information what they ignore, this real complexity that 'no scholar masters'" (Aubens and Benasayag 1999).

Indeed, this extension of a desire for social control is the result of crises linked to the emergence situations: the Chernobyl cloud, AIDS and contaminated blood, dioxins, mad cow disease, GMOs, Covid-19, etc., leading to a loss of confidence of society in scientific experts and in the powers that govern them (even if experts are required to be independent). There is, on the part of the public, suspicion and a

desire for moral superiority, even though generosity is always present in its actions in principle. Indeed, there is normally action in the name of an ethics of the good. However, it is possible to agree with Slama (1993) when he writes that "the intrusion of associative militancy into scientific territory takes on the appearance of an inquisition. It's a propaganda operation from which all oral criticism in the scientific field is eliminated". It is also important to bear in mind that, in the field of occupational hazards, which are often multi-faceted in origin, the responses of scientists and experts in the field to the public's demand for information are, for a variety of reasons, generally inadequate.

Indeed, for some scientists, the complexity of work may be an obstacle that can be circumvented by simplifying situations or, at best, by reducing them to the analysis of their elementary components (this is a classic return to our mono-disciplinary knowledge, effective but generally insufficient at providing an answer that takes all factors into account). The scientist then explores what they have understood about the issue, providing society as a whole with information that is normally honest, but partial and even truncated in its relationship with reality. In fact, there is a growing gap between the satisfaction of social demand, complex and immediate, and scientific responses that are marked by uncertainty and time consuming (André 2000), or even a translation into reductionism that is inoperable for the public through the use of forms of expertise.

This lack of understanding of the gaps between validated and robust knowledge, on the one hand, and the aspirations of the social body, on the other hand, is easily transformed into a trial of intent, combining nominalism, amalgam and Manichaeism (Slama 1993). The imperfect mastery of the links between accidents, on the one hand, and diseases, on the other hand, and working conditions induces, on the part of the public, a desire for social control tending toward persecution. It seeks action but does not have the means to act on the actual causes, hence the specific sensitivity to the search for pseudo-causes that it understands, as permitted by its culture. This is why they are so sensitive to the search for pseudo-causes that their culture allows them to understand, enabling them to express their discontent in a variety of ways. "Members of the crowd are always potential persecutors, because they dream of purging the community of the impure elements that corrupt it, of the traitors that subvert it" (Girard 1982). So the crisis is real:

– The victims are chosen not by virtue of the crimes attributed to them, but by virtue of their signs of victimhood, anything that suggests their culpable affinity with the crisis.

– First and foremost, the social insurer's and research center has a duty to provide scientifically and technically validated information on changes in the world of work: changes in technology, work organization, and the complex relationships between finance, the employer, employee, social insurer, state, Europe and the world.

– This "outside" knowledge is necessary to invest in the field of occupational risk prevention, inducing the development or adaptation of knowledge on measurements (allowing to check whether the regulations are followed), as well as (and rather above all) prevention engineering. This last strong component allows the advice of business actors with a view to improving working conditions within a socioeconomic framework and imposed standards.

In addition to these natural axes, work focused on occupational health has been developed, allowing the search for links between physical, chemical, psychological, organizational difficulties, etc., and the appearance of occupational diseases. This research was made possible by the knowledge that the institute (or its Western counterparts) has of the world of work and by the existence of structures acting internally in toxicology and epidemiology (and also perhaps because of the numerical weakness of researchers from national research organizations (NROs) acting on this theme of public utility which only imperfectly responds to the logic of scientific in-depth study and technological development enabled by research in engineering sciences).

Given all of the difficulties, even if all of the organization's forces were concentrated on the occupational health component (which, however, corresponds to less than a few thousandths of French research), it would be impossible for the research center to provide the minimum satisfaction to all social demands (numerical weaknesses and the need to anticipate emerging problems). This situation can be found in most developed countries. Even if this is a mission that complements the basic, information-oriented mission of the social insurer, it can be highlighted in the media because of the concerns and uncertainties associated with illness.

However, in the national context, there aren't any (or are few) organizations likely to cover this field of action. It is therefore (still) the INRS that is often considered, by those outside the social security as one of the main centers responsible for the development of knowledge in the field of occupational health. Even if, in France, these missions are now shared with national structures, it is sometimes assigned intentions that it does not have, in the name of a certain "socially correct", non-virtuous attitude, supported however by proven facts: accidents and illnesses.

And yet, its mission is to inform, in a way, to demystify: "It's not a matter of deciding for others, but of enabling them to do so, by their own means, by providing them with the elements enabling them to judge" (Revel 1988). In fact, this institute is given far too much scientific power and scope for action than is reasonable! The second element in the answer to the question, centered on the guilty affinity with the crisis, is linked to the specific nature of this organization's parity management. It is, in fact, administered by a genuinely joint board (unlike the other components of social security: sickness, old age, family allowances). Thus, the reading of

newspapers, following investigations by the General Inspectorate of Social Affairs (Desriaux 1999), aimed in principle to the study of possible links between INRS and the Institut de veille sanitaire (now part of ANSES), resulted in some powerful images of possible but effective employer control! The media's accusation is considered real by many, and naturally induces the bias necessary to reinforce suspicion. Finally, last but not least, money! If the institute is to be able to provide serious (and therefore validated) information to all corporate partners, it must have the means to achieve its objectives. It must therefore have sufficient funds to carry out its mission, without having to seek out private or other partnerships that may distract it from its public service activities. For some in the media, the institute's "riches" are real, but naturally misused, because they are linked to misdirected activities. The trial of intent is not far off. INRS thus has the third label, through the presence of a certain number of victim signs.

The aim of the operation is to shift the responsibility of this crisis and to act on it by destroying the victims, or at least expelling them from the community they "pollute". By classifying the organization as de facto controlled by the employer, marginalization necessarily follows by casting doubt on its "neutrality" or "transparency". But there are periods of "social peace" between crises. Moreover, many experts sometimes rightly consider that privately funded scientific publications are, on average, less "neutral" than those financed by the state. Without wishing to enter into this difficult debate, as each situation is a case in point, there are clear cases of "orientation" in writing (though perhaps not unilaterally), some of which have been the subject of legal settlements (Malka and Gregori 2005). According to Girard (1982), "ritual thought seeks to sacrifice a victim as similar as possible to the monstrous double. The marginal categories from which sacrificial victims are frequently recruited do not perfectly meet this requirement, but they are the least bad approximation". According to this author, the victim must naturally be made a stranger, isolated from others by limiting contact with "healthy" members of the community – in short, marginalized. This dialectic aims to channel forces within the limits by imposing ritual remedies. Does this not sound a little like Oedipus trying to kill his father?

If, in this situation, the public transfers its anxiety and to the scapegoat, the latter always loses out in the game of after-the-fact communication. Indeed, it is always difficult to lateralize a real problem by asking others to look at their own responsibility. It's also tricky to be able to justify yourself on every point. Indeed, in any human endeavor, there are always flaws. For the institute too, there is no such thing as zero risk, even if there is transparency in our activities (and if there had not been, would the public have been aware of the crises mentioned in this document?) So, the right of reply is difficult, and it is a delicate game, well known to communication specialists, a game they wish to avoid. When a crisis arises, how

can we try to communicate on a conflictual subject by purging the discourse of its passionate character and reducing it to its rational content (when it exists, insofar as we often find ourselves in conditions where the effects of innovations are not really under control)? In fact, this is practically out of the question!

In the social issues discussed in this chapter, given the complexity of information and regulatory systems, all of the players involved have their share of responsibility for the choices made then and now. Progress is (and always will be) necessary. In this way, the sacrificial myth is created as a "reaction to the decrepitude of behavior, the resurgence of consciences confronted with the spiral of irresponsibility" (Lipovetsky 1992). How, in this context, can we believe that generous and ideal proclamations and virtuous protests, will, with a vision of exclusion, make it possible, in particular at INRS, to always be up to the challenges that it must overcome in its mission of knowledge and prevention of occupational risks? This organization has therefore all four "qualities" of a scapegoat! These "cure, of course, neither real epidemics, nor droughts, nor floods. The crisis affects human relations inducing a process of bad reciprocity" (Girard 1982). External suspicion turns internally:

> Whatever their true causes, the crises that trigger the great collective persecutions are always experienced in more or less the same way by those who suffer them. The most vivid impression is invariably that of a radical loss of the social itself, the end of the rules and differences that define cultural orders (Girard 1982).

The constraints induced by "persecution" should naturally be passed on to the "victims" who unite against them by virtue of their belonging to minorities. If certain elements of the institute are attacked, other links in the system are left in the shadows, which may characterize a certain internal disassociation, reinforcing individualism and a certain desire to belong to "normality". Argyris (1999) shows that individuals often adopt defensive routines that insulate their mental models from any challenge (see also Heiderich 2007). It is difficult, however, to be both a member of the in-house team and involved in the destabilizing actions mentioned in this chapter. But this is all part of life...

One possible explanation for this situation is that all of the state-owned organizations, which avoid the "employer" bias (even if they have industrial contracts), are still in a position of relational stability and trust on the part of society. In principle, therefore, public authorities provide citizens with an element of operational reliability, even for research organizations such as CNRS, INSERM, INERIS and CEA, which are increasingly obliged to seek private funding in order to operate.

And yet, this same public is virtually excluded from the decision-making process! Clearly, "experts are unable, given the current state of knowledge, to provide confident answers to the questions posed, or to recommend measures to restore confidence" (Roqueplo 1996). This phrase is associated with the uncertainty of the scientist in relation to the complex issues of risk or vulnerability; it distances them from the dynamics of decision-making which cannot be directly expressed through the mastery of knowledge alone. Yet, as the same author reminds us, there is "an obligation, despite the inadequacy of scientists' knowledge, to provide the 'causal knowledge' required by policy-makers". In principle, there can be no identity between the scientist who defines knowledge and the expert who organizes it with a view to an end, which corresponds to the work of experts and deontological regulatory mechanisms (Lipovetsky 1992).

Slama (1993) points out that "the progression of social control measures to the detriment of individual autonomy and the transfer of democratic legitimacy to experts are slow, subtle phenomena, due to a necessity that is not perceived as ideological". It is this concept of expertise, which is insufficiently communicated, allowing for the alert is one of the criticisms sometimes leveled at INRS. Once again, there is an amalgam. In addition, Etchegoyen (1999) has identified six "perversions" in law and morality that "reveal flagrant contradictions between the two concepts of responsibility legal and moral responsibility":

– The desire to do nothing: legislation acts as a brake on risk, limiting innovation. "It is always more difficult to prove the responsibility for inaction than for action".

– Fear of punishment: "we forget the other in order not to forget ourselves. This fear in fact aims to suppress the moral concept of duty".

– Moral oblivion: "victims can't stand the fact that the perpetrators don't feel responsible or don't admit any moral responsibility"; compensation is not enough! Criminal law is being abused, illustrating the lack of moral responsibility.

– The impossibility of thinking about accidents: "we no longer support the idea of damage without those responsible who would be there to pay in every sense of the word, from revenge to compensation". This is one of the areas where we must invest in prevention to help, in particular, from the design of the processes, the partners of the companies.

– Deflecting it onto abstract causalities: "there is a flagrant contradiction between personal (moral) responsibility and that transferred to the company" (example: consumption of tobacco, alcohol, psychotropic drugs, etc.), the problem of compensation being outside of this concern.

– The obsession with definition: "you have to define everything to cover yourself for fear of punishment".

These various elements, highlighted in Etchegoyen (1999) and quickly recalled, are precisely the subject of the search for a redefinition that is undoubtedly very provisional in the social acceptability of risks. Multifactorial, long-term risks, which may affect offspring, are a source of concern:

> We know what place the delicate associations of falsity and sincerity occupy in our psychic activity; the need to believe, stronger than the desire to know; bad faith, by which we take the precaution of concealing the truth from ourselves to be more sure of our firmness, when we deny it to others; the reluctance to acknowledge an error, unless we can attribute it to our qualities; and last but not least, our ability to implant in our minds those systematized explanations of reality we call ideologies, a kind of machine for drawing out facts favorable to our convictions and rejecting the others (Revel 1988).

For other players in society-related research, this may be an opportunity to reaffirm their independence in judgment. By making it more visible to society, there is a way out of this vicious spiral. Or would it be necessary to practice a new form of holocaust, a true sacrificial act of expiation, so that the survivors can then act in a "socially correct" way, associated with the shame of the bad deed? This is what happened after Chernobyl (1986), in a different context! Thus, "modern insecurity does not consolidate anything, even by ricochet. Far from supporting it, it directly undermines social cohesion, sowing uncertainty everywhere. And what we see, when we look at the most insecure areas, is a stupefied, powerless community that begins to doubt the benefits of solidarity, in other words, of itself" (Peyrat 2003).

For the public, the research laboratories of large organizations are still adorned with a certain innocence, a humanism and a good taste of honesty, but the contractual relations which are today necessary for their dynamics can lead to certain unfortunate amalgams and, as a result, crises over a certain failure of the knowledge production system. Scientific articles are increasingly withdrawn (see Marchand (2022), in the case of the Covid-19 pandemic). The image of "beggars", which is often propagated, induces an effect of vassalization vis-à-vis the funder who, in return, is brought to bear the responsibility for his actions, but to what extent...

In fact, the list of irritating topics is growing: pollution of all kinds; suspicious burial of nuclear waste; nanotechnologies (Agora 2008; Sauvé 2008); convergence (André 2017); transhumanism (COMETS 2006); citizen control (Dutton 2004); Wi-Fi (Layet 2008); data files (see Edvige dossier withdrawn by the state, RF 2008), etc. In this new context of loss of public trust, it is not because we have expert organizations with the "right" victim symbols that public social agreement on academic research will be maintained in the long term. We therefore need to think

quickly about better relations between science and society; this is part of the researcher's mission. We need to take into account (Baude 2006) simple, robust principles such as:

– not giving the impression that there are stereotyped methods applicable to every situation;

– committing only to scientific facts and avoiding "social correctness" (Godard 2007);

– respecting the "ordinary" functioning of research: autonomy, validation by peers;

– respecting laws and ethical principles.

1.3. Modes of action

> It's quite true that all science is the result of individual experience, but there is another domain which is not individual experience and which is of paramount importance: it is the domain of morality, including the appreciation of moral institutions. And there are traditions that are not based on individual understanding or insight, but on the experience of groups that were selected for certain practices that may be purely habitual and have never been fully understood (Hayek 2022).

> In a culture saturated with technologies for appropriating our attention, our interior mental lives are laid bare as a resource to be harvested by others (Crawford 2016).

> Once upon a time, a ploughman was sweating in his field a few leagues from Baghdad. There passed before him a hideous and disquieting man, dressed in black and with evil omens. 'Who are you, stranger? Where are you going? What are you doing?' asked the peasant. In a voice that was surprisingly gentle and kind, the dark being replied: 'I am the plague, and I'm on my way to Baghdad, where I'll kill 500 people'. Some time later, having educated himself on the ravages of the epidemic in the capital, the ploughman suddenly confronts the man in black on the road. 'Hey, liar! Why did you tell me you were going to kill 500 people in Baghdad, if over 5,000 deaths have been reported?'. In the same gentle tone, the plague replies: 'I didn't lie to you, and it's not my fault. I only killed 500. The others died of fear' (Vallayes 2020).

In modern social systems, greatly disturbed by the media coverage of everything, the very strong time pressures and the inclusion in procedures of avoidance of social reactions favored by scientific uncertainties, lead, as has been widely expressed, too often to truncated debates. It is true that the disciplinary functioning of research (working in "silos") does not easily allow complex problems of interest to society to be tackled and favors this situation.

Moreover, when challenged, researchers generally prefer to confine themselves to their own system (of values?), a system in which their social responsibility is (still) a moot point. This situation is largely adapted to the physical, chemical and engineering sciences, where innovation comes first, and other aspects are best considered in later stages and handled by other players (it is this nonintegrated form of sub-contracting that is one of the reasons for the existence of safety research institutes in most developed countries). As already mentioned, the situation is quite different when research directly concerns human beings, where integration the visible impact of life sciences knowledge on the health of citizens (see, for example, UNESCO 2005).

In fact, as we have seen in recent "cases", leaving the researcher in contact only with his stakeholders and principals in a system not controlled by society can lead to dangerous drifts. Lavelle (2007) considers that "it is up to ethics [...] as the expression of a social demand of reflection and regulation, the ambiguous mission of assuming the shortcomings of politics. Ethics is thus called upon, rightly or wrongly, as the form of alternative thought and action most likely to limit the oversights, damage and excesses of technology and, moreover, to uphold the requirements of democracy".

While this may be acceptable, putting it into practice in the everyday research is not so simple, for a number of reasons that have to do with the spatial and cultural proximity of the various players involved. At the same time, society's desire to control research too closely can lead to equally totalitarian drifts, as a result of control by militant actors, the bearers of "opinion" often in the minority, but expressing themselves on behalf of society as a whole, and by the perennial display of the precautionary principle (a barycentric shift influenced by media noise). While it may seem suicidal to support the confinement of researchers to their ivory towers (disciplinary ghettos), it is important to think about ways of avoiding a blockage in the production of knowledge, the effects of which society will soon see. However, experience shows that the public has little room for maneuver in this context, as it is now obliged to accept technologies and consumer goods that have been decided elsewhere. The aim of SRR, presented below, is all about bridging the gap between the complex and diverse aspirations of the social body and the estimated effects (evolving over time) of the transformations of the world brought about by invention and innovation.

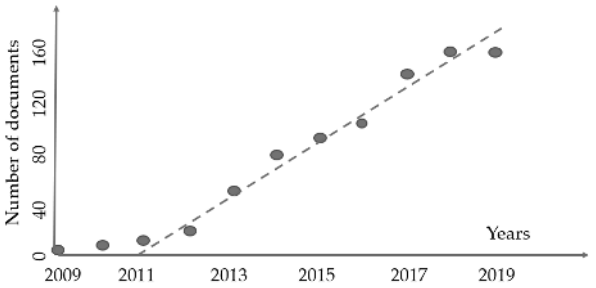

Figure 1.5. *Trend in the number of publications on the theme of research and innovation managers*

On this important topic, there is a wealth of work on conceptual thinking and empirical studies on the subject of innovation (Timmermans 2017). Moreover, this area has been promoted by the EU in its Europe 2020 strategy (EU 2019; Horizon Europe 2019) with the aim of making research and innovation more sustainable and inclusive. Figure 1.5, taken from Nazarko (2020), shows that this line of thinking has been developing over the last 10 years.

In essence, there is a great deal of asymmetry between specialists and laymen (Estrades and Rémy 2003; Cuppen et al. 2019), leading to misunderstandings with the creation of dissonance because the sequences of actions/behaviors can force us to readjust our positions before finding ourselves in a more coherent and ultimately pacified universe (Leroi-Gourhan 1965; Kaufmann 2008). The result may be the radical rejection of a new technology or a new product via the precautionary principle, which cannot be invalidated by the reductive authority of the "scientist", too confined to their own discipline, as they generally have no control over the consequences of the uncertainties associated with their inventive work especially if they are to be held accountable (Owen et al. 2013). According to Ramonet (1999), four cultures coexist in European countries: anthropological culture with its traditions and customs, humanistic culture (with its interest in Man, Nature, etc.), scientific culture ("knowledge for knowledge's sake") and mass culture, in which "information blurs into each other". According to this author, the connections between them are very weak. This chapter attempts to reconcile one form of scientific "angelism" with another form of social "barbarism", in an attempt to reduce the gap between the speed of "signs" and the slowness of the evolution of "meanings", and thus better justify the ends chosen from among all of the admissible ends.

To this end, without wishing to move to a system of "accounting" responsibility with relevant pseudo-indicators (see section 1.3.2), based strictly on explicit

contractual provisions (overly precise ISO 9001 or ISO 14000 "checklist"-type approaches, for example), possibilities for reconciling points of view are presented below (Dreyer et al. 2017; Rask et al. 2018; Shin and Park 2019; Walecka-Jankowska and Zimmer 2019; Yun et al. 2019; Owen et al. 2020).

1.3.1. *The project framework: socially responsible research*

> "The legitimate use of contradiction," adds Simone Weil, "consists, when the human intelligence is faced with the necessity of accepting two incompatible truths, in recognizing them as such, and in making of them as it were the two arms of a pair of pincers, an instrument for entering indirectly into contact with the sphere of transcendent truth inaccessible to our intelligence" (Weil 1955).
>
> Schumpeter's cumulative innovation is the primary source of growth: every individual will tend to under-invest in innovation, because he does not internalize the improvement in knowledge that an innovation brings to society. Knowledge that an innovation brings to society and the fact that other innovators in the future will be able to build on this knowledge (Aghion et al. 2020).
>
> There are historical moments of indecision or 'bifurcation' in which we don't know how a community or socio-cultural society will continue (Rosa 2020).

It is possible to hypothesize that the so-called "pure" sciences of conceptual deepening are a long way from immediate application. However, this proposition does not stand up to analysis, as the definition of regularities has led to numerous technical advances that we will not go into here. There are therefore probably no sciences, and in particular those concerned with artifacts, that are disconnected/separable from the social context. This can be seen in the proposals they submit to calls for tender, where many researchers, no doubt because they are asked to do so, mention the (sometimes fanciful or totally unrealistic) spin-offs of their future work in terms of applications. As stated in section 1.1, it is not easy to define a Mode 2 research activity in relation to "popular expression", since opinion is neither structured nor stable over time. It seems potentially useful to have an independent organization whose mission would be to inform (non-instrumentalized) scientific choices by collective decision to try to take account of the remarks made in this chapter (but is this easy to achieve?).

Indeed, research cannot function in a permanent and random interaction of opinion, particularly in response to unsubstantiated reactions (whatever the

field: scientific, social and/or political). In the absence of a structure such as the "Commission Nationale du Débat Public" (CNDP), which would engage in an in-depth discussion, the aim of socially responsible research is different. This assertion redetermines the researcher's responsibility, but in fact leads to a judgment a posteriori of their activity (contract of trust).

To this end, it could be proposed to award a label to research teams (unless this involves an internal cultural change, a form of self-certification) which, in addition to their scientific relevance and performance, propose to make a serious commitment to broadening their activity, with a view to reinforcing their position as a useful player in the social progress made possible by science. A non-exhaustive list is presented as follows:

– traceability: this investment is essential for building trust between partners, particularly with companies (quality approaches, best practices, etc.);

– responsibility compliance (*a minima*) of regulations research operations: protection of researchers and the environment;

– compliance with ethical laws (human experimentation, animal experimentation, data protection, etc.);

– originality/novelty: reflection on the launch of research operations whose outcome cannot be predicted from knowledge of the "prior art"; this means a better creation of knowledge, effectively new through scientific interdisciplinary projects. It means constantly questioning our own practices;

– conscious analysis of the uses of research results for society (this is a useful reflection, but difficult because of uses/transgressions of the same concept for different purposes);

– in-depth reflection on the uses of artifacts in society use and associated disruptions, recycling, risks of major irreversibility effects on the environment in the short, medium and long term; relations with mankind: risks, social justice and equity, development of the human personality;

– periodically revisit the various items in line with advances in scientific knowledge and their effects;

– mission to alert if new risk situations appear to be emerging.

In this way, following the example of CSR (corporate social responsibility), a research team/unit or group in charge of a pre-POC committed to "socially responsible research" in its operations, would do well to:

– comply with the ALARA (As Low As Reasonably Achievable) or general precautionary principles;

– undertake a risk analysis to (re)define appropriate protection methods, in a written document – a research team's operating charter – that can be communicated to the supervisory authority(ies). This approach gives teams a sense of responsibility and avoids the "crime of ignorance";

– inform the other laboratories/teams concerned (pooling of progress).

These various elements naturally need to be explored in greater depth, clarified and shared. They could lead laboratories engaged in these (new) practices to be awarded a possible "socially responsible research" (SRR) label. In this context, we need to analyze who would provide such a label, how the associated activity, what would be the benefits for research units linked to this label, how would we communicate with society on this important development. These elements are covered in sections 2.3 and 2.4.

NOTE.– CSR (corporate social responsibility).

CSR standards and practices are not imposed by law or treaty. They derive from the market, advocacy and investor expectations. They also require companies to behave in certain ways when operating abroad. While governments have encouraged the adoption of CSR standards, they have generally avoided legislating in this area as they have for environmental, social and governance standards (FI2020). Although they are geared toward risk disclosure, and therefore on a different plane to CSR, it is once again private-sector standards, independent of state regulation, that have a direct effect on corporate behavior.

According to Debref et al. (2019), this is a point of the ISO 26 000 standard. Its boundaries have expanded to include stakeholders (Donaldson and Preston 1995), to innovation processes, with upstream consideration of potential impacts on society (Pavie 2012), or by using social and environmental goals as a starting point for innovation (Ingham 2011; Temple et al. 2018). Innovation can then no longer be considered technological, as it must incorporate a principle of responsibility.

1.3.2. *Other considerations*

Several themes could be envisaged to operationalize the elements defined above. As this is a pilot action, this proposal for a possible charter could be reviewed periodically (if only in the light of regulatory changes and feedback). In fact, what we are looking for is a cultural change.

1.3.2.1. *Theme 1: aspects of "scientific performance"*

It would be useful to have a document defining the aims and means of the scientific research carried out in the pre-POC unit/group in relation to certain societal needs. It is a reflection document that defines what the group means by performance. It is only natural that there should be a gap between this reflective analysis and the traditional ways of defining this concept.

1.3.2.2. *Theme 2: legal aspects*

Compliance with the laws and regulations laid down by society through its representatives is a prerequisite for "socially responsible" research.

1.3.2.3. *Theme 3: management aspects of research under uncertainty*

In the absence of regulations, in terms of criminal liability, there is no liability without a text. However, if a case were to be brought before a judge in the event of exposure to risk or damage to others, the researcher's legal liability could be sought on two grounds (if the constituent elements of the offences are met) of the researcher could be sought on two grounds (if the constituent elements of the offences are met):

– criminal liability: the offence of deliberately endangering others (art. 223-1 of the French Penal Code) or a characterized fault that exposed others to a particularly serious risk that the perpetrator could not have been unaware of (art. 121-3 paragraph 4 of the French Penal Code);

– civil liability: the researcher has caused damage to others and may be held civilly liable.

NOTE.– In the current state of the file, there are no regulations specific to "uncertain risk" research, but the precautionary principle remains valid. It may be proposed that:

– The laboratory takes sole responsibility for an action involving uncertain risk and it relies on best practices validated by national or international agencies (this means that it has thought the matter through).

– The laboratory or pre-POC group questions its supervisory authorities about the validity of its wish to act in the field concerned. It is then up to the supervisory authorities, in conjunction with the group, to bring together experts who can either confirm the group's wish, or consider that responsibility should be taken at a higher level. At this stage, it is all about mutualizing thinking for "responsible" action.

1.3.2.4. *Theme 4: ethical and moral aspects*

Under no circumstances should responsibility be a tool that prevents science from pursuing its quest. We need to give priority to a plurality of viewpoints, in

other words, to a more deliberative, more controversial approach to science – in short, new forms of deliberative rationalism, because they are collective. In other words, we need to learn how to construct a scientific object and problem with other experts. Organizing debates, led by the research group, can be a way of better linking science, technology and society. In the case of more controversial research, the researcher's responsibility must be redoubled. At the same time, all exceptional situations, and the reasons of state or emergency invoked, can create situations of lawlessness. Therefore, "getting out of ethics" must not be equated with getting out of the law, which would lead to "nonethical" being legally conditioned. Let us not forget that researchers have a redoubled social responsibility, precisely because they are scientists, "savants" and therefore, in principle, entitled to be "knowers" and experts.

These various elements must therefore be taken into consideration, so that, in consultation within the unit/pre-POC and with the supervisory authorities, unit charters can be used to experiment and pursue, "in real-life situations", the improvement of confidence that the company (or certain segments of it) to allow scientific adventure.

1.3.3. *Socially responsible research*

> If you think about it for a moment, you'll realize that we all produce to satisfy the needs of people we know nothing about, just as we all live thanks to the efforts of people we know nothing about. Which means that the current interaction producing the volume of goods that sustains the world's population, is the work of people directed for ends they know nothing about, and other people relying on other people who know nothing about them (Hayek 2022).
>
> Our morality is not a creation of our reason and cannot be the creation of our reason (Hume 1975).
>
> Contradiction, as Plato knew, is the sole instrument of developing thought. But there is a legitimate and an illegitimate use of contradiction. The illegitimate use consists in combining incompatible assertions as if they were compatible (Weil 1955).

In general, based on forward-looking thinking, there are numerous action programs published by various countries (the United States, Canada, European Union, United Kingdom, Germany, France, etc.), essentially aimed at research operations (programming). The industrial sector, on the other hand, requires rules of good practice for its risk control and liability management, which may be found in

ISO or standardization (CEN). In any case, the absence of reliable information in terms of possible risks, we need to apply the precautionary principle, currently enshrined in the French Constitution. In this context, we need to define the conditions for maximum protection of research operators, as well as those around them (environmental issues).

If this information can be easily communicated, it is then necessary to examine the situation on a case-by-case basis, in order to define the conditions for "minimal" risk research at local level. Following the example of CSR (Wikipedia 2022), the "socially responsible research" (SRR) label should/could be awarded to laboratories that:

– comply with the ALARA "or general precautionary principles";

– engage in a risk analysis to (re)define appropriate protection methods, which will be the subject of a written document, the operating charter of a certified (?) research team, which can be communicated to the supervisory authorities. This approach gives teams a sense of responsibility, and avoids the "crime of ignorance";

– inform the other laboratories concerned (pooling of progress), for example through a national or European portal.

This label is a real application of Jonas' *Imperative of Responsibility* (1990), which aims for an ethical judgment on its activities (see Davis and Laas 2014). If it comes to that, it should rather be awarded by an organization independent of the researchers' supervisory bodies, an organization that will have been at the origin of a specific charter applicable to new technologies and for which there is not enough scientific knowledge about the dangers to enter into traditional risk management methods. A number of cases, from nanotechnologies to digital sciences (e.g. AI) could "ideally" serve as demonstrators of this new type of scientific operation. Drawing on the principles of CSR (Wikipedia 2022), the foundations of SRR, elements of sustainable development charters, could be as follows:

– SRR covers social and environmental issues in the work of a research team.

– SRR is not, and should not be, separated from the laboratory's action strategy, since it involves integrating social and environmental concerns into its activities.

– SRR is based on a voluntary concept.

– An important aspect of SRR is the way laboratories interact with their internal and external stakeholders and external stakeholders (employees, customers, immediate environment, supervisors, partners, etc.). A responsible research climate translates into trust and openness to others. It is more a question of dialogical than propagandistic communication (Arendt 1972).

To this end, the exercise of SRR implies a heightened and updated awareness of the environment, as well as respect for balance of interests of stakeholders. SRR respects Koslowski's (1998) reflection: "The ethical fact lies not primarily in suffering the suffering of others, but in paying attention to and avoiding the secondary effects of one's own actions on others". In this sense, the obligatory openness toward what is not directly productive can disturb or even disrupt the dynamic team's research dynamic (like quality in research). What is more, as De Pracontal (2005) reminds us, "the popularizer doesn't say science – it is unspeakable outside its context – he tells stories about science", and possible biases may exist in good faith between what the research says and what the citizen understands or simply perceives. Indeed, scientific jargon is sometimes polysemous and ambivalent, which can lead to misunderstandings.

For their part, Coller and Califf (2009) propose a series of questions for designers that constitute the beginnings of a self-guided global risk assessment tool:

– Does the planned use of the new technology meet a pressing need? What is its added value in relation to what already exists?

– What would be the size and type of market? With what probability of economic viability? How strong is the intellectual property?

– Is there an industrial partner to develop the technology effectively and efficiently? Will the technology have an acceptable price?

– Can a pre-study be designed, with sufficient statistical power or by any other method, to define a robust endpoint (Czajkowski et al. 2016; Pineo et al. 2021)?

Transferring knowledge outside the scientific context is therefore a delicate exercise, requiring time-consuming learning (and not always well recognized by research evaluators). In this context, it must be necessary, in order to change the culture of researchers, we need to send out the signals of a strong will on the part of the supervisory authorities: for example, recognition of an SRR label, training courses, (partial?) modification of evaluation methods support for international accreditation, etc. Should we not reflect on Roman's (1998) words on the ethics of responsibility: "It consists in taking into account the real, the existing, and therefore in renouncing certain convictions that can wait, while not renouncing certainties and long-term perspectives"? The demand for a mutualized approach between management and laboratories assumes that "an altruist can have a selfish prejudice" (Elster 2009), but above all that, the action will develop from a small number of volunteer laboratories who will commit to the process ("Kantian" operating rule) and who will encourage others to imitate them (Laffont 1975; Kreps et al. 1982).

In innovative experimental research, knowledge of the risks associated with materials, chemicals, artifacts, etc., is not always stabilized. This context calls for greater protection of the researcher's working environment, or more broadly of the environment "tout court", to avoid exposing society to potentially unacceptable risks in a context where there is no regulatory framework that are based on risk control. From a factual point of view, decisions based on the use of the precautionary principle can take the form of:

– a ban (temporary or permanent): request for moratorium (e.g. carbon nanotubes);

– a restriction of use;

– targeted information;

– requests for specific in-depth research on risks/dangers for researchers and the general public;

– "simple vigilance";

– a responsible expectation.

In a situation of uncertainty, several criteria should be assessed with regard to the implementation and impact of the planned research program: acceptability, observability and reducibility, on the one hand, and irreversibility, severity and plausibility, on the other hand. These considerations, based as far as possible on all validated knowledge, should reveal the "consistency" of the risk (potentially supported, plausible potential, hypothetical). With this in mind, Chevassus-au-Louis (2007) proposed the use of a hexagonal mapping defined as follows (see Figure 1.6):

– upper part: acceptability;

– upper left: reducibility;

– upper right: observability;

– lower part: severity;

– lower left: irreversibility;

– lower right: plausibility.

Plausibility means an analysis of the scientific "consistency" of the risk, by acceptability the potential attraction of the novelty for the general public; by severity (its potential: population concerned, magnitude, nature of effects, etc.); by irreversibility, the ability of the risk to be temporary; by observability (aspect that can be detected early); and finally, by reducibility, the possibility of taking

preventive measures. By assigning a value to each of these considerations, it is possible to situate a "center of gravity" of the possible risk on this hexagon, enabling more informed decisions on the possible risk. For this analysis, leading to appropriate measures, it is possible to implement suitable internal deliberation processes (possibly with external support).

In fact, the consultation of different partners is expressed through a diversity of currents revealing the dimension, complexity and tensions of emerging fields. This can lead to difficulties of "cooperation" between highly heterogeneous players, and potentially the same applies to the application of SRR in communication.

Indeed, for scientists, there are already balances of power between technological, scientific disciplinary purposes, transfer of knowledge to society, environmental and public health, etc. These separate characteristics often rely on an appearance of shared definition. In fact, the new field from a scientific or technological point of view is probably defined at least as much by purposes, "systems of meaning" as by a field of questioning or effective problems or even a list of industrial results.

The existence of a certain vagueness may be due to a lack of clarification on the part of the individual but also to the possibility of exploiting this unstabilized framework to act in a committed manner. In fact, a number of publications have highlighted the gap between scientific knowledge and its limited application in practice (Pfeffer and Sutton 2000, 2006; Rousseau and McCarthy 2007; Rynes et al. 2007; Runu 2021). In such cases, we can expect disfunctions or even breakdowns in dialogue between stakeholders. Observed in cases where uncertainty reigns (e.g. nuclear waste), knowledge of the diversity of representations is a prerequisite for positive and honest exchanges. However, for the most part, when researchers are questioned, they consider themselves as capable, through self-expertise, to act in a way that is adapted to the situation they are exploring (in this context, experience has shown that subjects that fall outside their remit or skills are rather neglected).

In fact, and in agreement with Morel (2002), self-expertise is the result not only of organizations' sluggishness and lack of responsiveness, but also of a culture modestly adapted to new situations involving activities that do not fall strictly within the "hard sciences", activities carried out in a context where the isolation of researchers and the pressure exerted on them suggest total autonomy. Moreover, for many, the difficulty of translating their research into a language adapted to others, a weakness of the will to immerse themselves in activities that are not very profitable and, moreover, at high risk (if certain parameters have been neglected, which risks leading to forms of "tight shielding"). In still infrequent cases, intercultural expertise develops, with classic but manageable difficulties of language, perception, balance of debates (depending on the personal visions of the actors present). This situation is

close to interdisciplinary treatments. So, several considerations/centers of interest can then be at work:

– disciplinary considerations: new knowledge, innovation, wealth creation, technical progress, care and medicine, technical risks, toxicity and resource management;

– ethical and moral considerations: prevention, ethics of life, preservation of life, intergenerational solidarity, sustainable development and long-term effects;

– surroundings of daily life: emissions, pollution, hygiene, safety, health, stress, living conditions and comfort;

– framework policy and social framework: priority to employment decisions, civic-mindedness, democracy, neighborhood solidarity (e.g. waste management), "policing" and associated security and terrorism;

– hierarchical considerations (formal or linguistic) leading to forms of silence, even for people who disagree with the proposals of the majority, the one who speaks up. There may be a number of reasons for this, including difficulty in explicitly verifying what has been said, fear of being incompetent, or submission to authority;

– risk of active pooling meetings being transformed into top-down information unacceptable storytelling, avoiding real open debate, a debate which is inherently fraught with uncertainty.

However, based on the best possible knowledge of the diversity of representations (which we should try to quantify (estimate), if only by assigning points to each of the responses to the proposed criteria), there is possibility of "honestly" having a clarification of the role/interests of the various actors with their identity facets, valuing diversity and the possibility of deepening the reflection on particular axes, but also of seeking other partners allowing, as much as possible, to balance the debate.

NOTE.– Integrity/reproducibility.

Plagiarism aside, these two areas are the focus of attention in the scientific world because they lead to non-robust interpretations. Already in 2016, Baker alerted the scientific community to this problem, recently taken up by Diaba-Nuhoho and Amponsah-Offeh (2021). It is no longer a question of being credible and inscribing ourselves in the "right" paradigm, but instead, that of being true. But, as we all know, this means that a certain number of constraints of the New Public Management paradigm (see Figure 1.6).

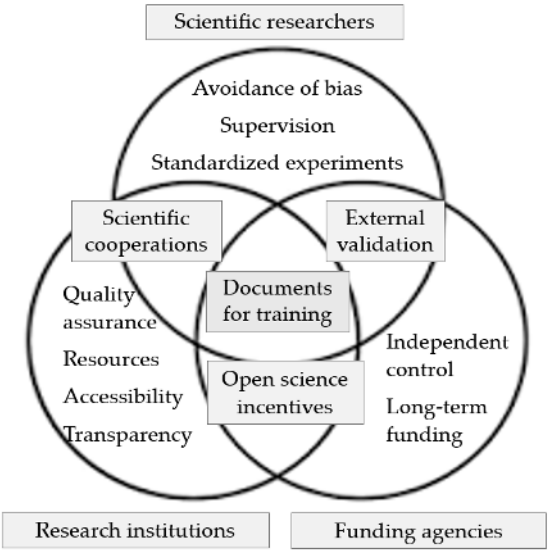

Figure 1.6. *Reproducibility and integrity in research: the role of scientists and their institutions*

In this sharing of a significant portion of ignorance, it must be possible to take stock of the uncertainties of scientific and technical knowledge, approximations of knowledge, misinterpretations and the limits of competence. It must also be possible to measure the extent of unresolved questions and question marks. Within the research team, this approach allows us to distance ourselves from all (?) ideologies, overly reassuring statements and oversimplifications. This means that there is a willingness to attempt to build a real action program from initial disciplinary understandings. The result must be a form of cognitive mutation that will force the rationality of expertise to take account of social demands (or what may take the place of them). This means that players must exploit facts and stabilized knowledge to the maximum, while at the same time taking heuristic account of uncertainty (the problem of building expertise). But to do this, we need a framework that is to move forward.

In this complex approach between scientists and laymen, the neutral aspect does not, in the final analysis, mean a neutral decision, based on the search for a soft consensus. It is possible to experiment to see how the dialogue develops during this period of high cognitive mobilization. Basically, as Reynaud (1989) reminds us, “the heuristic method is a bad method for proving, but a good method for discovering”. That is what is at stake in the approach we are proposing, as we try to rediscover meaning and coherence between the different partners involved.

1.3.4. *A few examples*

> All too often people rely on their own (limited) experience to make important decisions, they rely on a few successful examples (often in the sense of benchmarks), and policy makers often rely on one study or only a very few that they happen to have commissioned, and scientists all too often believe that only one or a few good studies really explain everything important about an issue (Frese et al. 2016).

> Incentives, without knowledge and systems, are likely to produce friction and frustration rather than change (Andrew et al. 2021)[4].

> By reversing the perspective on the gap between science and decision-making, we find that local administrators have a different view of this gap to scientists. Administrators seem to have a more nuanced, if not completely opposite, perception of the different epistemic contexts of scientists and decision-makers, of the uncertainty inherent in scientific knowledge and the rationality of decision-making (Van Stigt et al. 2015)[5].

To go further in practical terms, the precautionary principle is associated with the French "Barnier" law 02-02-1995 – articles L.200-1 of the rural code and L.110-1 of the environmental code – summarized below:

> The precautionary principle, according to which the absence of certainty, given *current* scientific and technical knowledge, must not delay the adoption of effective and proportionate measures aimed at preventing a risk of serious and irreversible damage to the environment at an economically bearable cost.

In innovative experimental research, knowledge of the risks associated with materials, chemicals, artifacts, etc., has not yet stabilized. This context implies reinforced protection of the researcher's working environment, or more broadly of the "just" environment, to avoid subjecting society to potentially unacceptable risks in a context where there are no regulations in place based on risk control.

From a factual point of view, decisions based on the precautionary principle can result in:

– a temporary (or definitive): request for a moratorium (e.g. carbon nanotubes);

– a restriction of use;

4 Author's translation from the French version of the text.

5 Author's translation from the French version of the text.

– targeted information;

– specific in-depth research on risks/hazards for researchers and the general population;

– "simple" vigilance;

– irresponsible waiting.

In a situation of uncertainty, several criteria should be assessed with regard to the implementation and impact of the planned research program: acceptability, observability, reducibility, irreversibility, severity and plausibility. These considerations, based on all validated knowledge, must reveal the "consistency" of the risk (potentially substantiated, plausible potential, hypothetical). Based on these considerations, Chevassus-au-Louis (2007) proposes the use of a hexagonal map as shown in Figure 1.7.

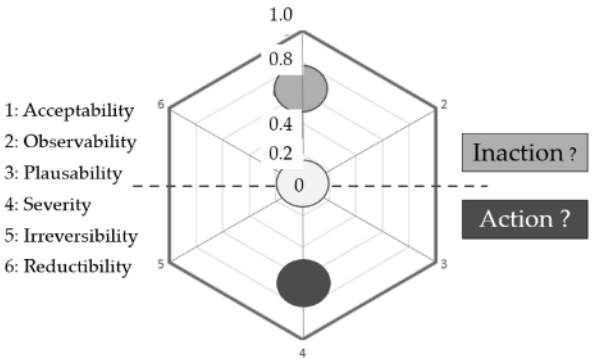

Figure 1.7. *Risk mapping for a decision in a situation of uncertainty*

Plausibility means an analysis of the scientific "consistency" of the risk (see above); by acceptability, the potential attraction of the novelty for the general public; by severity (of the risk) its potential: population concerned, magnitude, nature of effects, etc.; by irreversibility, the ability of the risk to be temporary; by observability (early detectability); and finally, by reducibility the possibility of taking preventive measures. By assigning a value to each of these considerations, it is thus possible to situate a "center of gravity" of the possible risk on this hexagon, enabling more informed decisions on the possible risk (but without quantifying it). For this analysis, leading to appropriate measures, it is possible to implement suitable internal deliberation processes (possibly with external support). On the basis of these exchanges, the unit/group may consider carrying out or requesting further research, reinforcing its scientific watch, or, more prosaically, considering stricter safety instructions, calling in external advice, etc. Two examples, taken from

de Bouet (2009), illustrate the possibility of using this proposal (see Figures 1.8 and 1.9).

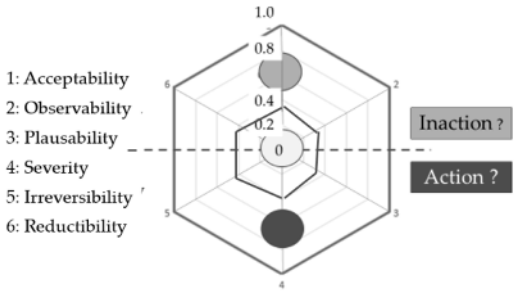

Figure 1.8. *The case of mobile telephony*

In the case of Figure 1.8, produced in 2009, this mapping does not lead to a clear-cut opinion; on the other hand, in the case of the handling of the "mad cow" crisis, the center of gravity of the polygon of risk indicators has shifted sharply downwards. At the time, this led to a radical solution involving entire herds, particularly in the UK.

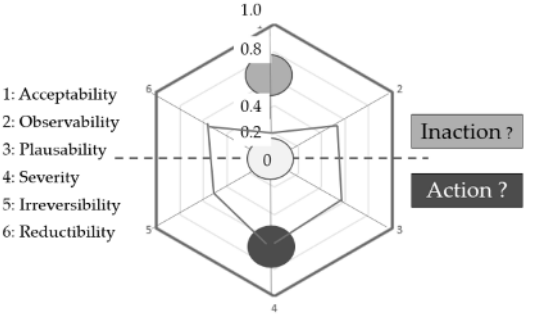

Figure 1.9. *Case of bovine spongiform encephalopathy*

Concerning the use of nanoparticles, in 2009 (HCSP 2009), the health watch group on the health impacts of nanotechnologies, attached to the school of the HCSP (*Haut Conseil de la santé publique*, French High Council of Public Health), recommended, on the basis of the precautionary principle, that the production of carbon nanotubes and their use for the manufacture of intermediate products or consumer products and health products are carried out under strict confinement conditions. It also proposes actions for identifying potential exposure and nano-safety situations, in particular for carbon nanotubes, and avenues for research

on metrology and risks. In this same High Council, it was possible to work on the risks induced by other nanoparticles such as nano-silver.

The HCSP (2010) has also examined the question of the safety of silver nanoparticles widely proposed for the elimination of microbes, bacteria and/or viruses. The opinion draws the attention of health authorities to a series of measures that should be carefully followed. These recommendations relate, in particular, to the monitoring system, product labeling and research that should be pursued in greater depth.

Finally, given that titanium dioxide nanoparticles are widely used in food, cosmetics and construction materials, and that they are manufactured or handled at numerous sites in France, which raises the question of exposure of workers and local residents, the HCSP (2018) has issued a recommendation to the French Ministry of Health. TiO_2 particles can contaminate the atmosphere, requiring specific protective measures, because these nanoparticles, inhaled or absorbed, cross biological barriers and accumulate in certain organs. However, the health risks are still uncertain. The HCSP therefore recommends:

– the protection and medical monitoring of workers handling these nanomaterials, in particular pregnant women and women of childbearing age;

– the application of good preventive practices in the workplace with regard to the production, handling, storage, packaging, transport and integration of TiO_2 particles into finished products, as well as recycling;

– protection of local residents and the environment around sites where TiO_2 nanoparticles are produced, stored and handled;

– the development of metrology and exposure monitoring in the workplace and the environment;

– the adoption of specific exposure limit values for TiO_2 nanoparticles;

– reinforcement of the obligation to declare the presence of nanoparticles in products and materials in the R-Nano database, by including substances with a minimum nanoparticle content of 10%, and making this database accessible to all organizations required to assess the risks of nanomaterials;

– that manufacturers and importers of TiO_2 include in their dossiers submitted for expert appraisal under REACH system studies on the reprotoxic potential of TiO_2 nanoparticles;

– support for research into the mutagenesis, carcinogenesis and reprotoxicity of TiO_2 nanoparticles;

– strengthening the resources of prevention organizations (INRS, Santé publique France, INERIS, ANSES) in terms of expertise on nanoparticles.

NOTE.– Acronyms.

– REACH: EU regulation adopted to better protect human health and the environment from the risks associated with chemical substances, while promoting the competitiveness of the EU chemical industry.

– R-Nano: enables manufacturers, importers and distributors of more than 100 g of substances in nanoparticulate form (nanoparticles, nanomaterials or nanotechnologies) to make mandatory declarations concerning the quantities produced, imported or distributed (see ANSES activities).

– INRS: *Institut national de recherche et de sécurité* (French National Institute of Research and Security).

– *Santé publique France*: national public health agency, a French public administrative body under the supervision of the Ministry of Health.

– INERIS: *Institut national de l'environnement industriel et des risques* (National Institute of the Industrial Environment and Risks).

– ANSES: *Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail* (National Agency for Food, Environmental and Occupational Health Safety).

Figure 1.10, which uses this mapping for these different nanoparticles, carried out with a group of volunteer students who were informed of the results of the literature from ENSIC (*École d'ingénieurs en génie des procédés* of the University of Lorraine), enables us to examine the differences in terms of the risks associated with these materials. The results are in line with the HCSP's three recommendations.

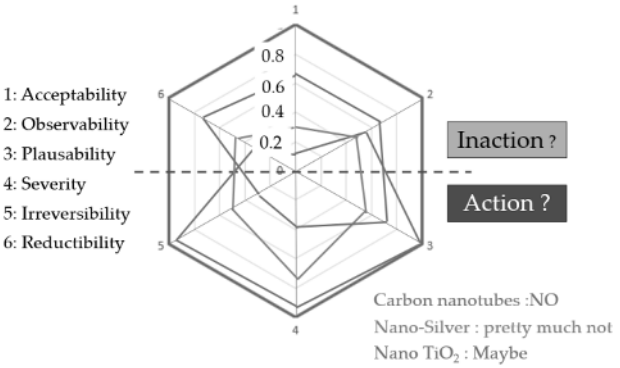

Figure 1.10. *Example of nanoparticles*

A group of experts must express their views on the interconnection of systems and unstabilized issues, taking into account as far as possible the effects and feedback on (current) practices of thought, science and action and so on. Expertise may find itself powerfully incited to undergo the anxiety generated by the emerging problem, forcing it to think urgently. With the Covid-19 crisis, a model, with unstabilized data, even absent from the pandemic, was carried out (Reversat and André 2022). Previous students were able to reflect on mapping applied to different citizen protection situations. The results are shown in Figure 1.11. However, according to Theys and Cornu (2019), several categories of questions seem to require priority attention:

– how scientific knowledge can be combined with forecasting and foresight;

– the choice of time "horizons", the determination of critical thresholds for action, and the taking into account by both scientists and stakeholders of the "time remaining to act";

– the concepts of "adaptation" to the perceived situation, the different meanings, the role of politics, international representation, etc;

– evaluation and historical analysis of the successes and failures of past attempts to frame collective action in time;

– reflection on decision-support tools, such as the prioritization of major irreversibilities or the discount rate.

These areas, as expressed in Figure 1.11, were only partially discussed with the students, for lack of time. In addition, the Covid-19 crisis presents society with the plan for the future in a context of extreme uncertainty. And yet...

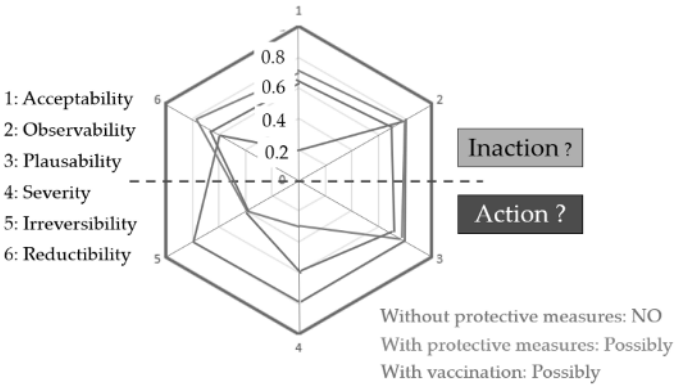

Figure 1.11. *Example of the Covid-19 pandemic*

NOTE.– Expertise.

In fact, the consultation of different partners is expressed through a diversity of currents revealing the dimension, the complexity and the tensions of the emerging fields. This results in difficulties of "cooperation" between highly heterogeneous actors. The same must apply to the application of SRR in communication. Indeed, for scientists, there are already power relations between technological, disciplinary scientific, transfer of knowledge to society, environmental and occupational or public health purposes, etc. These separate characteristics often rely on an appearance of shared definition. In fact, the new field from a scientific or technological point of view is probably defined at least as much by purposes, "systems of meaning" as by a field of questions or actual problems or a list of industrial results, etc. In these cases, we can expect malfunctions, or even breakdowns in the dialogue between stakeholders. As a result, in cases where uncertainty reigns (nuclear waste, GMOs, augmented human beings, for example), knowledge of the diversity of representations is a necessary prerequisite for the action of positive and honest exchange. Several considerations/centers of interest, repeating some of those expressed above, may be at work.

– disciplinary considerations: new knowledge, innovation, creation, technical progress, care and medicine, technical risks, toxicity and resource management;

– ethical and moral considerations: prevention, life ethics, preservation of life, intergenerational solidarity, sustainable development and long-term effects;

– framework of daily life: emissions, pollution, hygiene, safety, health, stress, living conditions and comfort;

– framework policy and social framework: priority to employment decisions, civic-mindedness, democracy, neighborhood solidarity (e.g. waste management), "policing" and associated security and terrorism.

Responsible research and thus refer to ways of proceeding at an early stage, obtaining relevant knowledge about the (possible) consequences of the outcomes of their actions and about possible scenarios, evaluating foreseeable outcomes and options in terms of moral values and using these considerations as functional requirements for the design and development of new research, products and services (Davis and Laas 2014).

Based on the best possible knowledge on the diversity of representations (which we should try to quantify, if only by assigning points to each of the responses to the proposed criteria), there is the possibility of clarifying role/interests of the various players, to value diversity and the possibility of deepening reflection on particular axes, but also to seek out other partners to balance the debate as far as possible. In this sharing of a significant proportion of ignorance, it must be possible to take stock

of the uncertainties of scientific and technical knowledge, the approximations of knowledge, the abuses of interpretation and the limits of competence. It should also be possible to measure the extent of unresolved questions and question marks. This approach should enable us to distance ourselves from all (?) ideologies, overly reassuring statements and oversimplifications.

To do this, you need time and a sufficiently composed or partially "neutral" framework in which to move forward. But neutrality does not mean neutrality in decision-making based on the search for a soft consensus.

1.3.5. *Authoritarian constraint*

> Man is not born carrying within himself the meaning of his life; we must necessarily conclude that no human society is possible where the normative arrangements have not been imagined and instituted, thanks to which the subjects of successive generations attain the status of human beings (Michéa 2006).
>
> Many moral philosophers and other thinkers live in a peaceful world, barely obscured by a few bands of cloud, and as they walk along the sidewalks that take them from their offices to their homes, they dream deliciously of intentionality (Richards 1993)[6].
>
> […] it is unlikely to be useful if the policy makers get too involved in the decisions on how these studies should be done, but they should rather encourage competing methodological approaches of evidence development to allow for triangulation (Frese et al. 2012).

In 2008, the European Union published a document entitled "Commission Recommendation on a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research". This document, which is intended to be general, attempts to translate into constraints, a number of principles to which the entire research community subscribes (even if they are only recommendations). In this new context, the need to change culture is perfectly well felt, but cannot be produced in such an "angelic" (?) and ultimately radical way as that presented by the Union in the document. Initial training, the disciplinary scientific approach, staff evaluation methods have shaped minds in all (or virtually all) areas of "academic" research. If exploring the social field is a priority, the approach needs to be validated, assimilated and appropriated. In short, it will take time (and money) for it to become an integral part of researchers' (good) practices. Indeed, it will be necessary to

6 Author's translation from the French version of the text.

disrupt the cognitive processes that will enable the culture of both researchers and stakeholders to evolve, leading to the adoption of more socially responsible behaviors (by accepting stops, revisits of scientific activities, questioning, etc.).

Moreover, in the field of exploring the dangers to health and the environment induced by nano-objects, France (as well as Europe) has a very (or too) limited number of good toxicologists capable of addressing these essential themes (remember that when the REACH procedure was set up, only a few percentages of the dangers of pure chemical substances used industrially were well known on a world scale, whereas the development of chemical dates back to the second half of the 19th century!). Under these conditions, where the need for technical progress is desired, research teams from various R and R&D organizations (CNRS, INSERM, IRSN, INRS, CEA, universities, etc.) and industries have shown that it is possible to define effective collective and individual protection of the various operators of research laboratories. In the absence of knowledge of the dangers, it is, in a responsible manner, preventive operations that must therefore be favored. In principle, there is already a way to avoid major problems at the design stage (up to the POC).

In a code of conduct designed to establish a calm debate on "nanoparticles", which is intended to serve the "well-being" of society as a whole, it may be advantageous to present possible risks, uncertainties, possible irreversibilities and the potential benefits of their development in a balanced way. Now, if we were to demonstrate the harmlessness of electromagnetic waves from cell phones, the advantages of this freedom (?) of connecting with other citizens be destroyed/ forbidden in the name of a low health risk? The vague concept of well-being introduced in the European document is insufficient to define appropriate rules. It is all about acceptability. We are well aware of its shortcomings, in particular its potential for manipulation, its temporal evolution and its sensitivity to "social correctness".

We can clearly see this today in the war between Russia and Ukraine, which is leading to sudden cuts in the supply of gas to Europe with a reversal of opinion regarding nuclear power. This simple situation dulls the entire operational scope of this European code. Moreover, in the field concerned, speaking generally of nanoparticles is like speaking of chemical risk, not all chemical substances are dangerous in the same way; globalizing is not solving the problem. It is therefore at the stage of the research team or of a group engaged in the definition of a pre-POC that it is necessary to integrate all of the problems associated with specific innovations, but not only for nanotechnologies alone, real point of crystallization of social concerns around 2010. These, as illustrated by André (2017) and Schaer et al. (2020), have largely evolved due to the lack of reliable data in sufficient quantities, the weariness of opponents and the temporary existence of other possible risks. One risk drives out the other, without always being treated.

The first point of the document states that this code "invites all stakeholders to act responsibly...". Clearly, it is not possible to develop "Mode 2" research in the sense of Nowotny et al. (2003, 2005), who hypothesize a concerted, "harmonious" choice between science, technology and society to develop "consensual" research. Various surveys carried out in the United States and Europe show that the public is quite unable to keep up with scientific developments, and probably even biased. When it comes to risk, are researchers able to plan ahead? Have they been trained to express risks heuristically?

Thus, and this is the whole SRR debate, feedback is due not only to the stakeholders, but also to the public, whose (difficult) understanding of the uncertainties linked to innovations should enable "peaceful" monitoring, rather than crises supported by certain players exploiting (too) many uncertainties. Unfortunately, not everything can be fully understood by the public. Translation is tricky and can leave room for many interpretations. This can lead to blockages and crises, as the irrational may be called into play (another risk management to operate). Nisbet (2009a, 2009b) considers it important in order to move beyond "polarized" and compartmentalized interpretations of an open question to engage voluntarily in dialogue with society. This means remaining faithful to scientific knowledge, but also avoiding denigration of the social groups involved. In any case, this dialogue cannot be seen as a strategic attempt to "sell" science (reverse storytelling), which is practiced even by consulting firms paid to develop language adapted to "requalifying" debates (Nisbet and Scheufele 2009); the aim is indeed to recognize the points of agreement between stakeholders and to understand each other on those at the root of disagreements, thus authorizing a process of progress.

The European document seems marked by a concern for fear of being accused of not having identified all of the potential problems linked to the application of "nano" research, leading to the assumption today of irresponsible activities on the part of the research and even industry. Beck (2003) and Jonas (1990) reminded us that we live in a society with risks and that the sacrosanct zero risk does not exist! Responsibility consists of making choices and assuming them at all levels, and it is indeed the goal of a democracy to commit to meeting the needs of society (avoiding as much as possible, naturally and obviously and reaffirmed, major and irreversible effects).

Moreover, as far as research is concerned, should we not rather speak of a precautionary attitude in the recommendation rather than the principle which comes under interdisciplinary expertise, carried out by scientists who reason in "complete non-knowledge of cause", in general, under time pressure and, then, validated (or not) by the state? We can, at the limit, understand that, on a vast social subject (apart from research) such as that of "mad cow disease", it was necessary to have a decision-making aid, because the problem was important (but scientifically localized) and likely to lead to a serious crisis; but how will we manage to define it

on a European scale, for each small specific case in laboratory research, the (good) rule to follow… It is indeed at the stage of the research unit or the pre-POC that it is necessary to act and to change the culture of the personnel. Thus, on this proposal, it is possible to make the following comments:

– There is no advantage in defining a code solely for the "nanos" component; information science and technology, information technologies, organizational changes, etc., have changed behavior to a very large extent without anyone being concerned, so why nanos? Because the invisible risk is more worrying than the known risk? To avoid blocking research, as is the case with GMOs?

– We must take into account the timeframes and wishes of decision-makers to achieve effectively responsible research with the costs that go "with it"; a cultural change cannot be decreed, it must be built.

– The European Union must set an example by providing significant funding to achieve the proposed objectives.

– The document says too much about what we must or must not do, and fails to explain how we are going to achieve the humanist objectives (unchallenged, because they cannot be challenged) recalled in this chapter.

– Do we not already have the necessary arsenal from an ethical, legal, regulatory arsenal that makes this anxiety-inducing, paranoid text useless for all parties?

So, in an attempt to be unassailable, reading this code gives the impression that nanomaterials only entail risks for mankind, whereas there are benefits already being industrialized and others, as yet unimagined, that could emerge. Naturally, there is a need for increased and shared vigilance, but it probably does not require all of this formal and impractical paraphernalia. Besides, by 2022, we will not be hearing any more about this "umbrella" document that only protects those who wrote it. It is another form of responsibility! Moreover, scientific research must not suffer the effects of a proposal from the Union that imposes obligations of results without the responsibility being shared at least with the European principals, some of whom contribute to research funding.

In this sense, this type of document is ill-suited to sharing social issues as part of a dynamic of innovation that could bring jobs, purchasing power, quality of life and a sense of community in a Europe that is still searching (even if changes are taking place with the Russia–Ukraine war). It is all the more dangerous because, after a quick read, the positive vision conveyed by the document (but which exists in other equally legitimate frameworks) will probably be retained by a reader in a hurry relative to its inoperability. If extended consultations are carried out under time pressure, it is reasonable to assume that responses to these requests for opinions will

be positive, with very few remarks. The "soft" majority will prevail over the minority who have thought things through because they are responsible.

The construction of a shared collective imaginary value-added of good governance must be one of the concerns of the European Union, which, from the author's point of view, probably has other things to do than to take refuge in a questionable appraisal of the future of nano-electronics, which is either ill-adapted to reality or biased, in order to satisfy who knows what group of players? Or, as mentioned above, to avoid being accused? The latter hesitates between an understanding of the document that respects a form of angelism associated with a "good conscience" (with, however, a transfer of responsibility!) and a possible more cynical intention to achieve/maintain a fake social peace. Where then is the added value and responsibility of the authors of this document?

The author's approach, as we have come to understand, is aimed at a commitment to the voluntary nature of certain responsibilities, forcing those involved in (necessarily risky) research to justify and explain their choices. The second, that of the document, consists more in denouncing a delegation of responsibility to these actors (Charbonneau and Estèbe 2001). According to Appel (2001), we find ourselves in a situation of "bifurcation architectonics" between moral standards and legal principles. In the former case, the aim is to promote the capacity for responsible autonomy, linked to ongoing evaluation by the researchers themselves, and more likely to be evaluated periodically and/or a posteriori by those in power.

In this situation, we come across the old debate between freedom and autonomy on the one hand, and obligation and duty on the other. Perhaps politics also does not want to be relieved of the fate of society by scientists (Marinese 2008), which is laudable in itself, even if the means to achieve the objectives are not defined. "Doesn't this rationalization of lawmaking [recommendation] ignore the irrationality of facts?" (Bergel 1993).

In this situation, we find an old debate between freedom and autonomy, on the one hand, and obligation and duty, on the other hand. The choice of autonomy is linked to a need to trust, because no "regulator" has day-to-day knowledge of what is done in the laboratory or in the informal group in charge of the pre-POC, nor of what is being prepared in the head of the researcher or the creative who has not yet been forbidden to think. Common ground between the two visions may exist, but it must be wanted in the name of a negotiated benefit for humanity. Moreover, in trying to move in this direction, it is useful to remember that our society, with all of its complex and evolving interdependencies, is defined less and less in terms of roles

and statuses. It is then difficult to assign an obligation to a single "target". It therefore seems important to enter into joint processes of sharing responsibility in a true spirit of consultation and cooperation. The Union document should, in this sense, commit to the consensual establishment of meaningful partnership arrangements.

1.4. Provisional conclusion

> Inventors tend to have their most impactful innovations around age 40 and their incomes rise rapidly just before they have high-impact patents (Bell et al. 2019).
>
> Decision-making, which can influence the structure of the social network is the need to create a consensus. As Whyte et al. (1989) note, the first task of all decision-making groups is 'to produce a consensus from the initial preferences of its members' (Kijkuit and van den Ende 2007)[7].
>
> The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist [...] It is ideas, not vested interests, which are dangerous for good or evil (Keynes 1953).

Beck (2003) reminds us that "it is no longer the scale of the risk that is changing, but its 'scientification', which no longer allows us to offload our responsibilities onto nature". Researchers can no longer remain in their cozy disciplinary silos and must, like everyone else, take an interest in the world by returning, albeit modestly, to a less modular, less mono-disciplinary, less mutilated production. To do so, it must participate in the coordination of production, with a view to achieving operational efficiency of interest to society (Berger 2006) and, consequently, open up to a culture shaped by the reductionism of linear thinking (Mariotti 2008).

It is not a question of defining a stable path for action, but rather a commitment to openness. Indeed, not everything can come from this one, ultimately privileged world; we must also bear in mind Girard's (2002) very important remark on society. He writes: "It's not that I believe in an intrinsic superiority of the still new fields of our culture – science, technology, economics. But, in my opinion, our cultural

7 Author's translation from the French version of the text.

activities are vulnerable in proportion to the spiritual greatness that should be theirs". SRR is probably one of the ways in which we can get closer to an anxious, ill-educated, ill-informed society with changing desires. It is, moreover, on the basis of this rapprochement that it may be possible to avoid untimely and random controls and crises, but this requires a responsible attitude that is ultimately new in its expression.

In any case, this radical change requires a real social will if we are to make research a socially useful tool for the long term, in a world that is exploring new paradigms. Yet, as Einstein (1991) wrote, "no problem can be solved without changing the mind that created it". This strong agreement runs the risk of being a rhetorical device using the lazy, easy route to "sloganized" imprecations that essentially boil down to a display. As we have said, it's as if it had already been done! In fact, this is one of the criticisms levelled at national politicians. All we need to convince ourselves of this is the proclamation of a desire, not really operational, to reduce the production of carbon dioxide for the environment. In a particularly important case, the European Union published a "nanocode" of good conduct on nanotechnologies (2008), highlighting a genuine desire to avoid any risks to people and the environment, which could lead to discernible blockages. Is public pressure (the possible asbestos effect) leading the EU to engage in pseudo "political correctness"?

In the absence of a real will on the part of all the stakeholders, which is quite likely, it will unfortunately always be possible to carry out fortunately useful disciplinary work. But how, and on what ethical foundations, will we define the future conditions of social utility enabled by the results of research in terms of invention?

According to Peyrat (2003),

> Socialization now requires a real project, to be deliberated, implemented and explained: the institution of a new urbanity. On a societal scale, we can no longer rely on automatisms to guarantee mutual trust. We need to create new conditions for its emergence.

Does the causal and enlightening case of new technologies, supported by all the funding bodies, basically not risk overshadowing or, on the contrary, revealing this necessary revisiting of the role of research into short-, medium- and long-term risks, in a world that is increasingly escaping the complex and ambivalent desires of mankind?

> Our entire destiny, with all its facets, depends on this ability [to meet challenges]. The reason for this is simple: can we for a single moment expect our culture, the values we hold dear, our potential for influence, our art of living, would not gradually fade away, if we were no longer able to take our place among the living, to take part in the

> global struggle, in the scientific, economic and technical fields? (Leprince-Ringuet 1980).

Another vision of responsibility...

These various elements, which are explored in depth in this chapter, need to be set against the processes that lead to invention and innovation. For example, as expressed by Aghion et al. (2020), there is pressure for growth, with renewals that can be radical (Schumpeter's creative destruction). Innovation is based on a cumulative process (waves of secondary innovations) in a favorable environment that allows competition. Even if we can envision a trusting dialogue between innovation and SRR, the result of this expertise, which we hope to share, can lead to failure (as in the case of the industrial development of carbon nano-tubes in France, for example). In this sense, the SRR axis is a "death valley"!

Death Valley No. 12: passing SRR's "filter" favorably

> Responsible research and innovation refers to ways of proceeding in research and innovation that enable those who initiate and are involved in research and innovation processes at an early stage (A) to obtain relevant knowledge about the consequences of the outcomes of their actions and about the range of options open to them and (B) to evaluate outcomes and options effectively in terms of moral values (including, but not limited to, well-being, justice, equality, privacy, autonomy, safety, security, sustainability, responsibility, democracy and efficiency) and (C) to use these considerations (under A and B) as functional requirements for the design and development of new research, new products and new services. (DGRI 2013)

In this context, is Leblanc (2020) right or wrong when he writes: "we have no choice but to keep fighting to be among the winners. But beware of the pacifists of the economy [supporters of SRR]: like all pacifists, they are just good at losing wars, not at winning peace!"?

1.5. Conclusion: from the 12 "Labors of Hercules" to the 12 "death valleys"

> We're dealing with the ideological whenever a signifying production is considered in relation to the basic mechanisms of social functioning as constraints on the generation of meaning (Veron 1979).

The creative imagination:

– "disappointing part of Man [...], mistress of errors and falsity [...], superb power, enemy of reason, which likes to control and dominate it" (Pascal);

– "error and disorder entering the mind, at the same time as the tumult of the body" (Alain);

– "essential poverty because the passive object is kept alive artificially" (Sartre; Gust-Desprairies 2003).

> I told you that [Man's] freedom consists of his power to act, and not in the chimerical power of wanting to want (Voltaire 2009)[8].

Hercules is the son of a god (and not just any god, he is Zeus) and a mortal (but still a princess), so he's a demigod. The gods of Olympus are complicated characters who intervene in all the world's affairs, making Hercules irresponsible but guilty of the death of his wife and children. He is therefore condemned to perform 12 impossible tasks as a punishment! He has the intelligence, courage and strength to fulfill his destiny. As with Hercules, not all the information needed for the path ahead (in this case, innovation) is available, and his success depends on mastering uncertainty and risk. That is where my recollection ends, but it is close to the 12 "valleys of death" evoked in Chapters 1 and 2 of Volume 1 and Chapter 1 of Volume 2, and recalled in Table 1.2 (see also Berkun 2007). These are not all consensual proposals, because some components of society (from research to the public) may (have) different cultures, desires and political visions, not all of which can be easily reconciled either between compartments, or within at least one of them. The polydispersity of points of view is one of the characteristics which means that an idea can become profitable or be rejected.

NOTE.– Interdisciplinarity.

"We can define 'interdisciplinarity' as that social phenomenon in which different epistemic cultures (Knorr-Cetina 1999) meet and dialogue, exchanging tools, theoretical and normative frameworks, as well as know-how, and often sharing common practical goals" (Di Vigni 2021).

These various interdependent items are shown in Figure 1.12, adopted from Kammoun and Le Bas (2020).

8 Author's translation from the French version of the text.

"Death Valleys"	Comments
No. 1: having a "good idea"	"Brilliant!" I've got an idea (am I a demigod?), and at this stage, is it recognized as such (by the sender, or even by others)? Having a good reason for a creative idea. Providing a framework to generate ideas (they can come from anywhere, in any work environment). Make people "dream" with divergent thinking.
No. 2: being able to integrate a convergence/divergence system	Going beyond the simple idea; giving it coherence and envisaging an inventive project (thought in terms of systemic processes); complexity. Considering known partners.
No. 3: an environment that supports convergence	Talking about it to give substance to the project (an idea is one thing, a functional solution is another), while maintaining a minimum of confidentiality, and involving known partners on the basis of availability, openness, scientific and/or technological relevance, etc. Joint approaches between the cultures of philosophy and engineering cultures.
No. 4: (still) having a creative idea, despite formal training...	Not being shy. See No. 1: between "real" training and the possibility of wandering, if possible "learned", while remaining credible or being "taken seriously". Risk-taking between disruptions not easily financed (associated risks) and traditional financial support for incremental activities.
No. 5: having a creative idea that is recognized as such **N° 5 bis: having a creative idea and integrating it into a rational approach**	Idea desirability. Validly associate partners to carry out a pre-proof of concept (specifications and heuristic approach). Paradigm and innovation process as proposed by G. Dosi as early as 1982. Invention from elements in complex interactions and systems analysis in an interdisciplinary context; complexity sharing and pooling through encounters, dialogues and exchanges of tools, theoretical and normative frameworks; integration. Thinking short-term for companies. Knowledge of the real and the possible. Breaking down and/or bypassing barriers. Considering a forward-looking approach.
No. 6: creating a POC in an interdisciplinary framework	To be financially supported and have the people and resources to carry out a POC heuristic approach and complexity. Designing a technology with markets that correspond to a "winning lottery". Finding the right path in a sprawling administration, the administrative maze is still in place, and even growing ("In 1980, Jacques Dominati, Secretary of State for the Civil Service, felt that we French had the best administration in the world. The proof: foreign delegations were constantly coming to our country to learn from us. Forty years later, his distant successor couldn't make the same remarks without triggering general hilarity, as the many recent examples speak for themselves" (D'Haraucourt 2021)). Patent application.

No. 7: supporting to reach the POC and beyond	Maintaining desirability; deciding to continue or stop. Major transition in complexity management to achieve the simplest proposition possible. See No. 6, but with the option of creating an industrial demonstrator (ID) taking into account socioeconomic criteria with feedback. KIS; ease of implementation; compatibility.
No. 8: existing and being supported globally by society	An approach recognized by the business world and the means to achieve it; potential desirability of the invention. See No. 6; the question of the market is raised. Risk-taking to create a market segment that did not exist before the new technology associated costs. Needing to reach the people for whom the innovation is perceived as a benefit; subsidiarity ease of implementation; compatibility. Estimating the effects on society performance, employment, environment, etc.
No. 9: access to co-creation	Decision-making. Finding partners (noncultural technicians) to help transform an invention into innovation moving away from a "linear" model to one in which two types of players are both co-producers and co-users of information and knowledge. Using heuristics to bring about the best change in a poorly understood situation and within the available resources. Staying on course with the allocated budget. What type of training is required before industrialization?
No. 10: arriving on time	Decision-making. Overcoming our obsession with the past. Numerous filters slow down the process, which can mean that an innovation to reach the market too late; the question of standards is part of this valley. Possibility of trial runs prior to production launch. What training is required before industrialization. The agreement concerns an ID with its entire application environment completed. The innovation was perhaps too revolutionary for its time. Knowledge of opposing processes and the implementation of their ideas.
No. 11: reaching the market	Effective desirability of innovation decision. Jungle of public support for innovation. Resolving the issues already raised. Possibility of pre-production testing and observability (are the effects of innovation visible?). Building a business model. Creation of a start-up, integration into a company's industrial production, etc. (outsourcing of R&D, etc.).
No. 12: passing SRR's "filter" favorably	Ethical activity to be taken into consideration; effects of innovation on society. Satisfying regulations (France is said to be the country with 400,000 standards!). Environment.

Table 1.2. *The 12 "death valleys" and associated criteria*

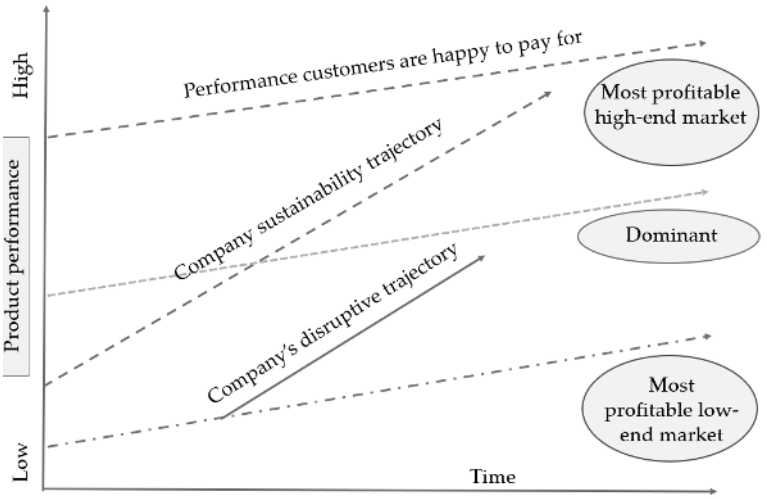

Figure 1.12. *Innovation trajectories*

Following the example of microelectronics with its Moore's Law (which is starting to lose its validity), the Western world succeeded in improving its technologies during and after the Industrial Revolution. In recent decades, the historiography of technologies has focused on radical breaks with the recent past. Within this temporal framework, the academic world has, according to Edgerton (2010), moved beyond a "thoughtless discourse on progress to become (in theory and in theory) eclectic, playful with time and open to marginality". He completes with these "definitive" sentences:

> We should be wary of favoring the novel, both in history and historiography, not out of conservatism, but because we understand the power and influence of claims to novelty to mask a lack of novelty, and sometimes even to suppress it. The promotion of novelty is itself profoundly lacking in originality, but old-fashioned futurism, though outdated, remains surprisingly effective. As [...] the Comte de Lautréamont said long ago, progress implies plagiarism but, we might add, not all plagiarism is progressive[9].

For Corichi García et al. (2018), no innovation is intrinsically disruptive at the outset; it is only through companies making strategic choices to position an innovation in a disruptive way that development takes place. While the first part of this two-volume work (Chapters 1 and 2 of Volume 1 and Chapter 1 of Volume 2)

9 Author's translation from the French version of the text.

showed the existence of many important factors associated with innovation, on a case-by-case basis, we find great differences between these criteria, so that in agreement with Taalbi (2017), a universal theory of innovation seems unrealistic.

As "keys to reading the world, the quality of goods and their accessibility constitute a privileged field of observation for reflecting on the future evolution of our societies". This predictive tendency is as much about "projecting contemporary concerns, hopes and events into the future" as it is about "acting on the present" (Belasco 2006). This is what we examine when we look at additive manufacturing technologies, presented below in the second part of this two-volume work (Chapters 2 and 3 of this volume).

NOTE.– In the South, little salvation?

Van de Vliert and Murray (2018) have produced an analysis of creativity that takes into account the intellectualization, industrialization and urbanization of society. Their results, shown in Figure 1.13, indicate a correlation that higher thermal demands hinder creativity in poorer populations, but promote it in wealthier ones.

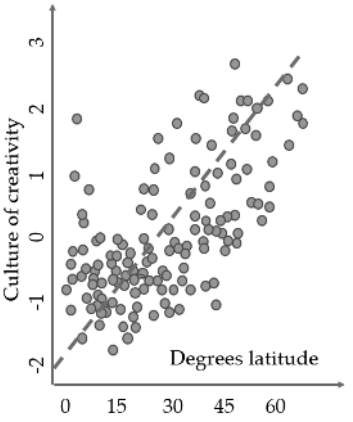

Figure 1.13. *Correlation between latitude and creativity*

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