Models of science and policy

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Chapter 16

Models of Science and Policy

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1. Introduction

In this chapter we will focus on the role of science in the development and implementation of policy. Specifically, we will present and briefly discuss a number of conceptual *models* that describe the relationship and interface between science and policy regulating environmental issues. These models come with their particular underlying assumptions, strengths and limitations, and no single model can be said to offer the universal solution to the challenges ahead, neither with respect to biosafety issues nor to complex environmental issues in general.

Nevertheless, we argue – along with a growing literature on these problems (see for instance Wynne 1992; Funtowicz & Ravetz 1993; Nowotny et al. 2001) – that a rethinking of the relationship between science and policy (and indeed politics) is called for. In the modern tradition of European Enlightenment, the relationship between science and policy was thought to be simple in theory, even if complicated in practice: science informs policy by producing objective, valid and reliable knowledge. To develop a policy was thus a matter of becoming informed by science and then, in a second step, to sort out diverse values and preferences. We call this the modern model. A crucial feature of this model is that it captures the modern notion of rationality. We could say in a simplified manner that, within the Enlightenment tradition, rational actors act within the modern model and choose those policy options that, according to the scientific evidence, best meet their preferences.

[1] The views expressed are those of the author and do not represent necessarily those of the European Commission

In theory, the modern model is easy to justify, to the extent that it is often taken for granted. Its justification, however, presupposes a number of assumptions that only rarely are expressed in full. First, it is assumed that the available scientific information is really objective, valid and reliable. When there is considerable scientific uncertainty, such as when the facts are highly uncertain, or when experts are in strong doubt, the modern model is no longer the unique rational design choice for the relationship between science and policy. The same would apply in the case where there are conflicts of interest, such as when the experts are themselves stakeholders. Second, the modern model assumes not only that uncertainty can be eliminated or controlled, but also that the scientific information can be complete in the sense that it tells the policy maker everything that is necessary to know in order to decide for the common good: there is only one correct description of the system, and it is to be provided by science. If there are several descriptions of the system, they might be combined and reduced into one all-encompassing scientific description. In other words, the modern model assumes that the system and the problem at hand are not *complex.*

The problem is that most important real-life environmental and health issues display both complexity and scientific uncertainty, posing serious challenges to the modern model. Basically, there can be three reactions to this challenge. The first is denial: to pretend that the challenge does not exist and keep using the modern model as it is. The second is accommodation: to try to adjust the modern model to confront the challenges of uncertainty and complexity. The third is to search for innovative, more radical departures from the modern model. Each of these possibilities will be briefly discussed in this chapter. It is only fair, though, that we admit that our main interest lies in the articulation of potential radical alternatives. We believe that recognition of irreducible scientific uncertainty and complexity in environmental and health issues necessitates a fundamental departure from the modern model, revisiting its definition of knowledge as well as of governance. Knowledge is not only produced by science, and governance is more than deducing action from facts and preferences. Our reasons for believing so will be presented in the following.

2. Theoretical Framework: Sources of Uncertainty and Complexity in the Biosafety Issue

As noted in the Introduction, many authors and strands of thought currently point towards the inadequacy of the Enlightenment tradition to meet emergent challenges, and the need to rethink the relationship between science and governance (including policy and politics). Beck (1992) has discussed how modern societies routinely produce not only goods but also *bads*, in the form of risks, due to the adverse and often unanticipated effects of progress. The accumulated magnitude and unequal distribution of these risks gradually become more severe and more apparent with the passage of societies to the post-industrial stage, to the extent that it becomes a key feature of our time, which Beck calls *second modernity*. Nowotny et al. (2001) emphasise the emergence of transient innovations research (so-called *Mode 2*) at the expense of the established university disciplines and their celebrated academic (Mertonian) ideals. In their view, the emergence of Mode 2 research is a logical response to ongoing developments in the economy and technology and the inadequacy of university disciplines to deal with these problems. In their work on *post-normal science*, Funtowicz & Ravetz (1990; 1993) have analysed how the presence of irreducible uncertainty and complexity in environmental and technological policy issues necessitates the development of alternative problem-solving approaches and interfaces between science and policy, in which uncertainty is acknowledged and science is consciously democratised. Finally, in Lyotard's (1984) description of the post-modern condition, many thinkers have found inspiration for the investigation of the colonialist and intolerant aspects of the Enlightenment tradition that imposes its standards and models of science and governance upon all other cultures.

It is not unlikely that there is a certain core of cultural critique common to all of the aforementioned theoretical strands, although we would expect that each of them would produce slightly different insights when deployed on a given topic. This means that although we will not discuss the biosafety issue from the perspective of, for instance, Beck's theory of reflexive modernisation in this chapter, we would like to encourage others to do so as this might stimulate supplementary relevant insights. The point of departure of our analysis, then, is that of *post-normal science*, based on the recognition of complexity and scientific uncertainty. Hence, we will briefly address different types of uncertainty and complexity, which are inherent in the biosafety issue.

In line with Funtowicz & Ravetz (1990), we may distinguish between *technical*, *methodological* and *epistemological* uncertainty. Technical uncertainty is a matter of questions such as ‘How many digits are reliable?’ while methodological uncertainty is the uncertainty related to the choice of research methodologies and methods. In terms of statistics, it is a matter of significance and confidence. Epistemological uncertainty – *episteme* signifying knowledge in Greek – is referred to by questions such as ‘What can be known about this phenomenon?’ and ‘How do we know that we know?’

To show that there is ample uncertainty in the biosafety issue, little more is needed than a glance at the Cartagena Protocol on Biosafety (CBD 2000). For instance, in Annex III (Risk Assessment), the Protocol states:

> *8. To fulfil its objective, risk assessment entails, as appropriate, the following steps:*
> *(a) An identification of any novel genotypic and phenotypic characteristics associated with the living modified organism that may have adverse effects on biological diversity in the likely potential receiving environment, taking also into account risks to human health;*
> *(b) An evaluation of the likelihood of these adverse effects being realized, taking into account the level and kind of exposure of the likely potential receiving environment to the living modified organism;*
> *(c) An evaluation of the consequences should these adverse effects be realized;*
> *(d) An estimation of the overall risk posed by the living modified organism based on the evaluation of the likelihood and consequences of the identified adverse effects being realized;*

In other words, it is necessary to estimate the likelihood, and the consequences, of potential adverse effects of novel genotypic and phenotypic characteristics of GMOs that by themselves are novel and emergent biological constructions on the planet. Imagine an estimate of a likelihood of P = 0.000374 of the possible occurrence of ecologically harmful horizontal gene transfer from a given agricultural GMO. What is the standard deviation of this estimate? By which methods should it be calculated? Controlled laboratory experiments typically yield reproducible and reliable data, but their validity under other conditions may be unclear. Should one demand field trials, and in that case, in what surroundings, monitoring which other species? Is general ecological knowledge on, for instance, biological invasions and natural hybridisation relevant and to be included in the calculation of the estimates

(Strand 2001)? The methodological uncertainties are so vast that technical uncertainties may appear irrelevant.

What about epistemological uncertainty in this case? What *can*, in principle, be known about the possible effects of novel and emergent artificial organisms? We cannot answer the latter question anymore than anybody else can. We can, however, show that the answer necessarily depends upon at least two crucial non-scientific factors: metaphysics and politics.

If the adverse effects to be studied are restricted to a small number of species and a short time-frame, it appears more likely that they could be monitored, or even perhaps some day predicted, than if one considers a large number of species and a long time-frame. The same applies if the problem is restricted to direct effects, and second- or higher order indirect effects and feedback cycles are not considered. In other words, how the problem definition determines what can be known and influences the uncertainty at all levels. This is not only a question of the overall number of effects to be taken into account, but also the specific choice of which effects to take into account. For instance, direct effects on production and profit are inherently more easily monitored than effects on, for instance, insect biodiversity.

Furthermore, there is a trade-off between the types of uncertainty. If one accepts a high level of technical uncertainty, allowing ‘fuzzy’, imprecise, qualitative, and anecdotal information, there is much more evidence available, which presumably would decrease the epistemological uncertainty (Marris et al. 2001). Often, however, such evidence is discarded as ‘unscientific’ because it is not cast in a precise quantitative form. In summary, there are a number of choices and decisions to be made on the framing of the problem affecting the research to be performed, which are not purely scientific (although the decisions often are made by scientists).

Metaphysics (or better, natural philosophy) also enters into the picture as the biosafety issue always requires an extrapolation from the known to the novel and emergent organism or novel deployment and use. The philosophical question to be addressed is: ‘What about potential surprises?’ Some scientists, decision makers and citizens have a propensity for *complexity*, and tend to think that Nature has a large capacity for surprises. Others tend to think that science knows more or less all that is worth knowing about Nature’s behaviour, and that surprises are unlikely or manageable. Both sides have some evidence to show in support of their beliefs. The latter refers to a large series of scientific successes, both in the theoretical and applied realms. The former similarly points to a large series of surprises and failures to control the surprises, as well as the development of chaos theory, complexity theory and other fields of research that show the limitations of linear models of Nature. We call this a metaphysical question because neither position is evidence-based today, and because we believe natural philosophy or worldviews play an important role in individuals' formation of beliefs (Strand 2002).

These philosophical subtleties about complexity are not irrelevant to the policy dimension, because from the perspective of complexity theory, uncertainty may be an essential and irreducible characteristic of systems and problems. In such cases, the rational option may be to increase efforts to *cope* with the residual uncertainty rather than wasting resources on uncertainty eradication.

3. The Evolving Relations between Science and Policy

What is the role of science in the governance of biosafety? And, more generally, what should be the relationship between science and policy?

First, we should clarify that there are two entirely different types of relationships between science and policy. The one hitherto discussed is that of science as *informing* policy. However, science is also the *object* of policy, in the sense that a number of policy decisions regulate scientific practice, above all in the life sciences and biotechnology. Likewise, it may be seen that the science that informs policy may successfully or unsuccessfully try to eliminate or reduce uncertainty, but at the same time scientific and technological practices are among the main world uncertainty *producers*, introducing novel and emergent technologies, organisms and forms of life. It is exactly this potential for innovation that currently enjoys the focus of attention in the research policies of many countries. With no more physical land on the planet to colonise, science (together with outer space) provides the 'endless frontier' to be conquered and capitalised upon (Bush 1945; Rees 2003).

On the other hand, the potential for unexpected surprising and possibly negative collateral effects is becoming increasingly acknowledged in the context of second modernity. The challenge, however, is that our societies have not developed the institutions required to handle the situation. Indeed, it appears that the main responses to production of uncertainty are those of 'ethical regulations' in the case of the medical life sciences and 'risk assessment/management' in the case of the science-based technologies, while the underlying assumption of the general desirability of accelerating research and innovation rates is left unchallenged.

In what follows, we will concentrate on the science that informs policy. However, the two distinct types of relationship between science and policy cannot be entirely separated. Sociologically, there may be connections or even overlap between the experts who inform and the scientists whose interests are affected by the policy decisions (De Marchi 2003). Epistemologically, there are definitely connections, in the sense that the practices to be regulated are based on a body of knowledge that also plays an important role in the policy advice. In more concrete words, in biosafety judgements, biotechnology expertise has often been given the central place, as opposed to, for instance ecology or sociology. We will return to this point later in this chapter.

As for the policy-informing function, we argued above that there are ample sources of uncertainty and complexity in biosafety issues. Alvin Weinberg (1972) coined the term 'trans-scientific' for 'questions which can be asked of science and yet *which cannot be answered by science*' (p. 209, original italics). Weinberg offered the example of the health risks of low-dose radiation, but he also discussed the general problem of weighing the benefits and risks of new technologies, decades before the debates on cloning, human embryonic stem cells, nanotechnology, and climate change arose.

It appears to us that Annex III of the Cartagena Protocol (as cited previously) is full of Weinberg-type of questions, and that biosafety issues on the whole might belong to the domain of trans-science. The problem is what to do about it. The *solutions* have been captured into five ideal types, or models, by Funtowicz (2006). We will present and briefly discuss them with regard to biosafety in the following.

3.1 The Modern Model of Legitimation

This model was already presented in the Introduction: science determines policy by producing objective, valid and reliable knowledge. Accordingly, to develop a policy is a matter of becoming informed by science and then, in a second step, sorting out values and preferences in order to formulate the correct and rational policy.

The idea of legitimation is central to this model. It is not a recipe for the articulation of policies; it is far too idealised for that. The key idea is that of a mutual legitimation. Governance and the foundation of the modern state are legitimised by the privileged status of scientific rationality. The modern European state also gradually adopted and supported the emerging scientific institutions to the extent that they achieved a hegemonic position as the official knowledge producers. The institutions of modern science and the modern state have co-evolved, justified and supported by the entire modern philosophical tradition since Descartes and Hobbes. Popper perhaps gave it its definitive form: science is the only guarantee of the open democratic society, and vice versa. According to Latour (1993), what happens is an ingenious mental division of labour. On the one hand, science is given the right to define (non-human) Nature and tell the truth about it, while staying clear of values and subjectivity. Politics, on the other hand, is given exclusive right to deal with values in society, but must leave questions of facts and truth to science. The achievement of making the citizens of modern societies think along these lines is the result of the philosophical endeavour of what the modern model is part, an effort that Latour calls the ‘work of purification’. In Latour’s view, the irony of modernity is that this mental work of purification is accompanied by a massive work of mediation between Nature and society through science: more and more connections among natural and human-made phenomena are established. Life technologies are changing the human condition and human activity is changing Nature (and perhaps has already irreversibly changed the climate). From the Latourian perspective, this irony is not accidental. It is exactly because modern societies have been led to think that nature and society/politics are completely separate realms, that they have accepted and endorsed the accelerating technological development.

This is not the place to discuss all the important features of the modern model. We hope to have shown, however, that a lot more has been at stake in defending this model than just the need to formulate an efficient policy-making strategy. The modern model has played a crucial part in the legitimation and consolidation of science, governance and political institutions in modern societies. It has also worked at a deeper cultural level in the modern state, securing the belief in the Enlightenment, progress and the superiority of the secular, Western scientific-economic rationality expressed quantitatively. On an anecdotal and biographical level, we have often experienced that interlocutors will defend the modern model wholeheartedly and not just for pragmatic reasons. For some, it appears to be also a matter of identity and hope.

The problem arises then, (i) when complexities abound, (ii) when uncertainties cannot be reduced to probabilistic risks, and (iii) when experts disagree, are seen to be stakeholders themselves or simply do not know. The following three models can be seen as attempts to fix these anomalies (Kuhn 1962), to adjust and rescue the modern model from the challenges of uncertainty, indeterminacy and conflict of interest.

3.2 The Precautionary Model: Rescuing the Modern Model from Technical and Methodological Uncertainty

In real policy processes, it is quickly apparent that the scientific facts are neither fully certain in themselves, nor conclusive for policy. Progress cannot be assumed to be automatic. Attempts at control over social processes, economic systems, and the environment can fail, leading sometimes to pathological situations. During recent decades, the presence of uncertainty has become gradually acknowledged, in particular with regard to environmental issues. Because of the incompleteness in the science, an extra element in policy decisions is proposed, namely precaution, which otherwise both protects and legitimises decisions within the modern model. The second model to be presented here introduces the precautionary principle or approach into the modern model, in particular in the way it is being used in the European context.

Precautionary ‘principles’ and ‘approaches have been introduced into a number of conventions, regulations and laws, notably the Rio Declaration on Environment and Development (UNEP 1992), the Cartagena Protocol on Biosafety and the 2001/18/EC Directive on the release of GMOs (see Chapters 29 and 30).

The exact description of the precautionary principles and approaches vary. However, the 'double negative' formulation of the Rio Declaration is illuminating and typical:

> *Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.* (Principle 15)

In the Communication of the European Commission (EU 2000: 1) on the precautionary principle, reference to scientific uncertainty is made, but it is emphasised that the precautionary principle is 'particularly relevant to the management of risk', and that

> *[t]he precautionary principle, which is essentially used by decision-makers in the management of risk, should not be confused with the element of caution that scientists apply in their assessment of scientific data.*

In the same communication, the Commission emphasises how arbitrary claims of precautionary measures cannot be supported by the precautionary principle. It is only to be invoked where a scientific evaluation concludes with evidence of risk, and only where precautionary measures are consistent with the principle of proportionality (between costs and benefits). This has prompted some critics to argue that the precautionary principle, in this and other similar formulations, is no more than an extended cost-benefit analysis.

Various episodes in the short history of biosafety illustrate the limitations of the precautionary model in the management of uncertainty. In the controversies surrounding Pusztai's studies on GM potatoes, and later, Quist & Chapela's (2001) studies on maize, much of the discussion centred on the scientific status of their claims. In the 1989–1999 controversy on the alleged harm to monarch larvae by transgenic pollen (Losey et al. 1999), the EU Scientific Committee on Plants likewise maintained that there was 'no evidence to indicate that the [product] is likely to cause adverse effects' (see for instance Scientific Committee on Plants 1999).

The normative principle of precaution is accordingly framed and expressed in terms of quantitative science. One may ask about the difference in practice between the precautionary model and the modern model, given that scientific evidence is never 'certain'. The answer appears to be that there are situations where the scientific community largely believes in the existence of a certain harm or risk although the scientific evidence is not yet conclusive according to normal scientific standards. In other words, concrete and specific evidence of harm exists, but the technical and methodological uncertainty is slightly larger than what the standard conventions of scientific journals allow (usually 95% confidence in the case of statistical uncertainty[2] (see also Gigerenzer 2004) (see also Chapter 17). Epistemological uncertainty, of the type 'we do not know what kind of surprises this technology could lead to', would be rendered unscientific and unsuitable by the precautionary model. This limitation is so severe that a complete reformulation of the principle is needed in order to accommodate epistemological uncertainty. In our view, it would have to be decoupled from science and from the future: a 'real' precautionary principle would not be contingent upon what will happen in the future, because this cannot be known. It would have to be framed by what is at stake today.

3.3. The Framing Model: Rescuing the Modern Model from Indeterminacy

We have discussed so far how a number of framing decisions may affect in a crucial way the outcome of scientific advice, as well as the resulting policy. With reference to biosafety, framing decisions include choice of types of effects, arrays of safety measures, species, scope of time and place, expert communities, and even scientific disciplines to consult. The virtually endless multitude of alternative framings is related to Wynne's (1992) concept of indeterminacy. There are no simple algorithms to resolve all these issues. Hence the framing of the relevant scientific problem to be investigated, even the choice of the scientific discipline to which it belongs becomes a prior policy decision. It can therefore become part of the debate among stakeholders. Different scientific disciplines themselves become competing stakeholders; whoever *owns* the research problem will make the greatest contribution and will enjoy the greatest benefits.

[2] It should be kept in mind that the 95% threshold is due to convention and a result of history. Ronald A. Fisher, the leading statistician in the development of statistical tests and the concept of significance, wrote: 'It is open to the experimenter to be more or less exacting in respect of the smallness of the probability he would require before he would be willing to admit that his observations have demonstrated a positive result. ... It is usual and convenient for experimenters to take 5 per cent as a standard level of significance' (Fisher 1951: 13).

Institutions are well aware of the problem of indeterminacy and of potential disagreement among expert communities. In an attempt to establish guidelines for the use of experts (COM 2002:713 p. 2), the European Commission states:

> *The Commission might be confronted by a panoply of conflicting expert opinions, coming variously from within the academic world, from those with practical knowledge, and from those with direct stakes in the policy issue. These opinions may be based on quite different starting assumptions, and quite different objectives. ... Increasingly, then, the interplay between policy-makers, experts, interested parties and the public at large is a crucial part of policy-making, and attention has to be focused not just on policy outcome but also on the process followed.*

The various attempts at accommodating the modern model to this challenge can be summarised in a framing model. The aforementioned guidelines primarily foresee an enlightened debate within the administration about how to frame the issue and choose the experts; other developments under the keyword of *governance* also envision participation by citizens and stakeholders in the framing process prior to scientific investigation – so-called upstream engagement.

However, an incorrect framing of the problem (e.g. due to error, ignorance, poor judgement, and not necessarily wilful) amounts to a misuse of the tool of scientific investigation. Yet because there is no conclusive scientific basis for the choice of framework, it has to be admitted that, to some extent, the choice is arbitrary (or social), and certainly not a matter of 'objective science'. Acceptance of the principle of framing entails an acceptance of some degree of arbitrariness of choice (ambiguity), hence of the possible misuse of science in the policy context and, moreover, of the difficulty of deciding whether or not a misuse has occurred. Indeed, the judgement will itself be influenced by framing.

The framing model is interesting for several reasons. It can be seen as an attempt to acknowledge and somewhat redistribute the power balance between experts and lay people: the non-scientific framing exercise that scientists often implicitly (and unselfconsciously) perform, is taken away from them and democratised, at least at a superficial macro level. The framing constraints built into the methodological details of the scientific investigation, as well as the appropriation of knowledge by science, are not addressed. One could probably instruct experts to include harm to monarch larvae in their list of relevant biosafety issues, but the problem would still be under-specified. In order to know of and to specify all the crucially important criteria for quality of evidence to avoid any indeterminacy, non-experts would have to be experts and could just as well do the research themselves.

The framing model had precursors in the 20th century political culture: above all, certain Marxist and feminist intellectual traditions that had an ideological understanding of the framing issue and the existence of diverse perspectives. Their preferred solution was standpoint theory, that is, that political class, gender or other markers of political starting points should be the selection criteria. This is not without relevance in the biosafety issue; indeed, in many debates it is observed that experts or studies are discredited because they are identified to multinational corporation, countries or NGOs. Such framing claims are quite different to allegations of corruption or scientific fraud. Ideas of politically progressive, 'red' or 'green' counter-expertise belong to this intellectual tradition.

The aforementioned European Commission guidelines (COM 2002:713, p. 9) resolve the issue of indeterminacy in the framing by calling for a plurality of perspectives:

> *The final determinant of quality is pluralism. Wherever possible, a diversity of viewpoints should be assembled. This diversity may result from differences in scientific approach, different types of expertise, different institutional affiliations, or contrasting opinions over the fundamental assumptions underlying the issue.*
>
> *Depending on the issue and the stage in the policy cycle, pluralism also entails taking account of multi-disciplinary and multi-sectoral expertise, minority and non-conformist views. Other factors may also be important, such as geographical, cultural and gender perspectives.*

This might work only if the framing problem is one of bias and tunnel vision of each type of expertise: pluralism may then result in robustness, cancelling out the particular biases, hence approaching inter-subjective knowledge. Unfortunately, the framing problem cuts deeper – it is a matter of necessary choices, not of unnecessary biases. This cannot be accommodated by the framing model because it retains the ideal of certain scientific knowledge at its base.

3.4 The Demarcation Model: Rescuing the Modern Model from Conflict of Interest

The last adjustment of the modern model to be considered in this chapter is the demarcation model. This model resembles the framing model in the acknowledgement of expert disagreement and bias. However, both diagnosis and prescription are different. Where the framing model sees the need to specify better the values to be included in the experts system, the demarcation model is more concerned with supervising the values in action in the process of creating scientific advice:

> *The scientific information and advice used in the policy process is created by people working in institutions with their own agendas. Experience shows that this context can affect the contents of what is offered, through the selection and shaping of data and conclusions. Although they are expressed in scientific terms, the information and advice cannot be guaranteed to be objective and neutral. Moreover, science practitioners and their funders have their own interests and values. In this view, science can (and probably will) be abused when used as evidence in the policy process. As a response to this problem, a clear demarcation between the institutions (and individuals) who provide the science, and those where it is used, is advocated as a means of protecting science from the 'political interference' that would threaten its integrity. This demarcation is meant to ensure that political accountability rests with policy makers and is not shifted, inappropriately, to the scientists.* (Funtowicz 2006)

An example of the demarcation model is the desire for a clean division between risk assessment and risk management. Another is the attempt to establish 'independent' studies or research groups, and perhaps also the insistence on 'sound science', both of them keywords in the GMO controversies.

The main problem of the demarcation model is that it is no longer functional except in clear-cut cases of corruption. Post-empiricist philosophy of science showed that, in general, a total separation between facts and values is impossible, precisely because of emerging systems properties such as complexity and indeterminacy. Concretely, when the situation is highly polarised and conflict is apparent, it is extremely difficult to have a watertight separation between risk assessment and management. How do we decide (and who decides) in practice which is an input of fact and which is an input of value? Stakeholders may be experts (farmers and fishermen, for instance), and experts may be stakeholders (entrepreneurial science). This does not imply that expert are generally misled, corrupt or notoriously subjective, only that the ideal of isolated scientists having access to 'God's eye view' is unrealistic, and probably undesirable.

4. The Model of Extended Participation: Working Deliberatively within Imperfections

The alternative models described in this chapter can be considered as a progression from the initial modern model with its assumption of the perfect effectiveness of science in the policy process. Concerning the precautionary, framing and demarcation models, the imperfections can be seen to form a sequence of increasing severity, admitting incompleteness, misuse and abuse. There is still the desire, in each case, that the link between science and policy remain direct and unmediated. Respectively, the three models address the challenges of uncertainty and complexity by enabling precaution to modify policy, by including stakeholders in the framing of decision problems, and by protecting scientists from political interference. However, the core activity of the modern model, the experts' (*desire for*) truth speaking to the politicians' (*need for*) power is left unquestioned and unchanged. In what follows, we will question the legitimacy of this core activity, and sketch an alternative model of policy that arises from that questioning. We call this the *model of extended participation*.

The underlying ideas of the model are those previously developed by Funtowicz & Ravetz (1993) in their writings on post-normal science. When a policy issue is complex, decision stakes are high and facts are uncertain and/or in dispute, scientists may still endeavour to achieve the truth, but the many *truths* of the systems to be decided upon are simply unknown and, in any case, not available at the timescale of the decision. This does not imply that scientific knowledge is irrelevant; it does mean, though, that truth is never a substantial aspect of the issue:

> *To be sure, good scientific work has a product, which should be intended by its makers to correspond to Nature as closely as possible, and also to be public knowledge. But the working judgements on the product are of its quality, and not of its logical truth.* (Funtowicz & Ravetz 1990: 30)

To some extent, and in some cases, one might be justified to simplify the matters by dividing the task of quality assurance into an internal and an external component. The internal component would then correspond to the peer review system of academic science in which fellow scientists examine to what extent the scientific work has been conducted according to the methodological standards of the discipline. The external component would correspond to an assessment of the policy relevance of the advice. In sum, the issue of quality assurance would then have been divided into *facts* and *values* components. However, as discussed (when explaining the shortcomings of the framing and demarcation models), such a simplification would often be unjustified. Epistemologically, such a division renders invisible the relevance of political values for the myriad of methodological choices in the scientific work (the value-laden quality of facts), as well as the relevance of scientific information for the governance processes leading to the settling of relevance criteria. Sociologically, the simplification presupposes a clear division between disinterested and always self-critical scientists within a Mertonian academy and the lay public who by implicit contrast cannot be granted critical abilities.

We do not think that any of these assumptions holds in the general case. Curiosity-driven, economically-disinterested research is becoming the exception rather than the rule in ever more research fields. The mere expansion of the research world has led to worries about the quality of its own internal institutions for quality assurance, i.e. the peer review systems. On the other side, the knowledge and the critical capacities of the 'lay public' is becoming recognised as the ideology of scientism is giving way. Furthermore, with the development of Information and Communication Technologies (ICTs), access to technical information is increasingly hard to monopolise (in spite of the attempts of a corporate research world to close its open society into one of capitalising upon intellectual property).

The logical implication of this state of affairs is to extend the peer review community and let everybody contribute to the quality assurance process: allow the stakeholders to scrutinise methodologies and scientists to express their values. Hence, the vision drawn by the model of extended participation is one of democratisation, not just for reasons of democracy, but also with the aim of improving quality assurance. In this model, citizens are envisioned as both critics and creators in the knowledge production process. Their contribution is not to be patronised by using, in a pejorative way, labels such as local, practical, ethical, or spiritual knowledge. A plurality of co-ordinated legitimate perspectives (each with their own value-commitments and framings) is accepted. The strength and relevance of scientific evidence is amenable to assessment by citizens.

5. Conclusions

Quality assurance can thus be seen as a core commitment of post-normal science. Defined in terms of uncertainties and decision-stakes, quality assurance encompasses public interest, citizen, and vernacular sciences. In a period of domination by globalised corporate science, this effort to make scientists accountable to interested groups presents a coherent conceptual alternative for the survival of the public knowledge tradition of science. Collegial peer review is thereby transformed into review by an ‘extended peer community’.

There are now many initiatives for involving wider circles of people in decision making and implementation on policy (environmental, health, etc.) issues. For these new types of policy-relevant problems, the maintenance of scientific quality depends on open dialogue between all those affected. This we call an extended peer community, consisting not merely of persons with some form or other of institutional accreditation, but rather of all those with a desire to participate in the resolution of the issue. Since this context of science is one involving policy, we might see this extension of peer communities as analogous to earlier extensions of the franchise in other fields, such as women’s suffrage and trade union rights.

Hence, extended peer communities are already being created, either when the authorities cannot see a way forward, or when they know that without a broad base of consensus, no policy can succeed. They are called citizens’ juries, focus groups, consensus conferences, or any one of a great variety of other names; and their forms and powers are correspondingly varied (see Chapter 34 for models of participation). Their common feature, however, is that they assess the quality of policy proposals, including a scientific element, on the basis of the science they master combined with their knowledge of the ways of the world. Further, their verdicts all have some degree of moral force and are, as such, a contribution to governance.

These extended peer communities will not necessarily be passive recipients of the materials provided by experts. They will also possess, or create, their own extended facts. These may include craft wisdom and community knowledge of places and their histories, as well as anecdotal evidence, neighbourhood surveys, investigative journalism, and leaked documents. Such extended peer communities have achieved enormous new scope and power through the Internet. Activists in large cities or rainforests can use their weblogs to participate in mutual education and coordinated activity, providing themselves with the means of engagement with global vested interests that are on less unequal terms than previously.

The existence of extended peer communities and what is often called ‘broader approaches to governance’ is today uncontroversial in many parts of the world, while their justification still remains controversial. We will briefly address the practical and theoretical aspects of their justification. The practical aspect can be summarised as follows: if the function of extended peer communities is that of quality assurance, what will be the source and commitment to quality in order to replace the collegiate mutual trust of traditional research science?

The answer to this question could start with an analogy. There are many negotiations in the worlds of policy and business that work well enough to keep the system going. The operative ethical principle is called ‘negotiation in good faith’. This concept is well established in many proceedings worldwide. It is sufficiently clear in practice for legal sanctions can be applied when one side fails to respect it. There is no reason to assume that technically trained experts are better equipped to practice this than are citizens. With such a regulative concept, there is no reason why dialogues in post-normal science situations should be lacking in the means to assure quality.

The theoretical aspect of justification is the question of legitimacy of the model of extended participation. By what argument do we claim that a de-differentiation of modern societies is legitimate, inviting citizens into the co-production of knowledge, and experts into the co-production of politics? As should be clear from the entire discussion of this chapter, the argument is based in a critique of modernity. Rather than beginning with the legitimacy of the extended peer community, we observe that the legitimacy of the modern model, with its strong demarcations and dichotomies between facts and values, and science and politics, is *dependent upon the intellectual work of purification* (Latour 1993). The work of purification, however, can only be legitimised metaphysically or by recourse to its pragmatic successes. In a world in which there is no monopoly on worldviews and the problems of second modernity are ever more evident with respect to natural resources and the environment, the unconditioned legitimacy of the work of purification evaporates. What we are left with, is the world, inhabited and owned by everybody. Accordingly, the model of extended participation provides justification in the absence of forceful arguments in favour of exclusion. The type of justification is different, however, from that of the modern model. Leaving the modern model behind, legitimacy is no longer ensured by a technical argument proving the optimality of an algorithmic model of policy making.[3]

Finally, and returning to the issue of biosafety, it is not for us to specify the possible value of the model of extended participation. That extended participation takes place, is evident. In Northern Europe, this may take the form of consensus conferences and technology *fora* organised by the authorities, while in other countries NGOs and popular movements often play a more predominant role.

It is contrary to the idea of extended participation that we try to specify the legitimate domains of interest of such processes. In particular, we think that one ought not to abstain from what could be seen as a *politicisation* of the discourses and governance processes; indeed, the issue of biosafety is politicised as a matter of fact. Rather, it appears that the technical discourses of risks (and in some cases, the emerging technical discourse of bioethics) act so as to conceal the political nature of the issues. Indeed, one might foresee that broader governance with an extended participation might be able to increase the scope of vision of the issues related to biotechnology, asking not only ‘Is it safe?’, ‘What are the known risks?’ or ‘Is it contrary to ethical principles?’ within a capitalist logic of added value from innovation, but also ‘Is it desirable?’, ‘What do we not know?’ and ‘What kind of future do we want?’

References

Beck, U. (1992) Risk Society: Towards a new modernity, Sage, London

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[3] Obviously, there are circumstances in which there are valid arguments to support marked differentiation of expertise but to extrapolate and rely only on that knowledge uncritically is unwise (Wynne 1992; Lash et al. 1996).

Bush, V. (1945) Science -The Endless Frontier, A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945 (United States Government Printing Office, Washington: 1945), http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm. Latest accessed 4 June 2007.

CBD (1992) Cartagena Protocol on Biosafety (http//www.biodiv.org/biosafe/protocol)

De Marchi, B. (2003) Public participation and risk governance, Science and Public Policy 30, 3, June 2003: 171-176.

EU (2000) Communication from the Commission on the precautionary principle (COM 2000:1), Brussels

EU (2001) Directive 2001/18/EC of the European Parliament and of the Council on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC, Brussels

EU (2002) Communication from the Communities on the collection and use of expertise by the commission: principle and guidelines (COM 2002:713), Brussels

Fisher, R.A. (1951) The Design of Experiments, 6th edition. Oliver & Boyd, Edinburgh.

Funtowicz, S.O. & Ravetz, J.R. (1990) Uncertainty and Quality in Science for Policy. Kluwer, Dordrecht, p.7-16.

Funtowicz, S.O. & Ravetz, J.R. (1993) Science for the post normal age. Futures 25:739-755.

Funtowicz, S.O. (2006). “Why Knowledge Assessment?” in A.G. Pereira, S.G. Vaz and S. Tognetti (eds): Interfaces between Science and Society, Greenleaf publishing, Sheffield, 138-145.

Gigerenzer, G. (2004) Mindless Statistics, The Journal of Socio-Economics 33: 587-606

Kuhn, T. (1962) The Structure of Scientific Revolutions. University of Chicago Press

Lash, S., Szerszynski and Wynne, B (ed.) (1996) Risk, Environment & Modernity – Towards a New Ecology, TCS Sage, London

Latour, Bruno (1993) *We have never been modern*, Harvard University Press, Cambridge Mass., USA

Losey, J.E., Rayor, L.S. and Carter, M.E. (1999)Transgenic pollen harm monarch larvae Nature 399:214

Lyotard, J.F. (1984) The Postmodern Condition: A Report on Knowledge. Transl. Bennington G & Massumi B. Foreword by Jameson F. Minneapolis: University of Minnesota Press & Manchester: University of Manchester Press.

Marris, C., Wynne, B., Simmons, P., & Weldon, S. (2001). Public perceptions of agricultural biotechnologies in Europe: Final report of the PABE research project. Lancaster, UK: University of Lancaster.

Nowotny, H; Scott, P and Gibbons, M. (2001). Re-thinking science: knowledge and the public in an age of uncertainty. Cambridge: Polity Press

Quist, D. and Chapela, I.H. *(*2001) Transgenic DNA introgressed into traditional maize landraces in Oaxaca, Mexico. Nature 414:541-543

Rees, M. (2003). Our Final Hour, Basic Books

Scientific Committee on Plants (1999). Opinion of the Scientific Committee on the Invocation of Austria of Article 16 ('safeguard' clause) of Council Directive 90/220/EC with respect to the placing on the market of the Monsanto genetically modified maize (MON810) expressing the Bt *cry*ia(b) gene, notification C/F/95/12/02, 1999.

Biosafety First: Holistic Approaches to Risk and Uncertainty in Genetic Engineering and Genetically Modified Organisms; Traavik, T. and Lim, L.C. (eds.); Tapir Academic Press, Trondheim, (forthcoming)

Strand, R. (2001) The role of risk assessment in the governance of genetically modified organisms in agriculture, Journal of Hazardous Materials 86:187-204

Strand, R. (2002) Complexity, Ideology and Governance, Emergence, 4:164-183

UNEP, Rio Declaration on Environment and Development (1992), http://www.unep.org/Documents.multilingual/Default.asp?DocumentID=78&ArticleID=1163. Latest accessed 4 June 2007.

Weinberg, A. (1972) Science and tran-science. Minerva 10:209-222

Wynne, B. (1992) Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. Global Environmental Change 2:111 - 127

Our linear, deficit model of science for policy was in many respects exhausted. It was clear that we were going to face more and more difficulties in fulfilling our mission of â€˜putting science into the heart of EU policymakingâ€™. So, we started to experiment with and develop a new model which we call Science for Policy 2.0. First, we focussed on better understanding the ever-changing policy world by interacting more closely with policymakers.Â Science and policy differ on multiple grounds: in the way they define and approach problems and solutions, the nature of their ques-tions, timeframes and time horizons, attention spans and breadth of perspectives, attitudes to uncertainty. An overview of theoretical models of scientic advice to policy-makers shows that among scholars there have been opposing logics and conicting views regarding the ideal mode of communication; some of these still remain unresolved now. This paper oers a brief historical overview of the most prominent models that show how the debate has evolved across time.Â We start with Habermas, who in the 1960s systematized a number of core models of how science and policy-makers can work together in his attempt to illustrate how the political system can â€œadaptâ€ to the growing complexity of modern society. The science of science policy (SoSP) is an emerging interdisciplinary research area that seeks to develop theoretical and empirical models of the scientific enterprise. This scientific basis can be used to help government, and society in general, make better R&D management decisions by establishing a scientifically rigorous, quantitative basis from which policy makers and researchers may assess the impacts of the nationâ€™s scientific and engineering enterprise, improve their understanding of its dynamics, and assess the likely outcomes.Â The Science of Science and Innovation Policy (SciSIP) program was established at the National Science Foundation in 2005 in response to a call from John Marburger for a "specialist scholarly community" to study the science of science policy.