Technology Assessment Policies – Making Framing Assumptions Explicit

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Abstract

Curiously similar patterns of change have emerged in recent years in the frameworks used to analyse both processes of technological innovation and science-based regulatory policy-making. In both domains, linear models have been replaced by circular models. This paper argues that models that were over-simplified have been replaced with models that are overly complicated. While linear models have often been invoked to justify over-simplified policy measures, circular models provide policy-makers with even less guidance as they suggest that you cannot change anything without changing everything and there is no conspicuous starting point. An alternative revised linear model is introduced, which unlike previous linear models does not start from 'scientific facts' but from normative aims and objectives.

Introduction

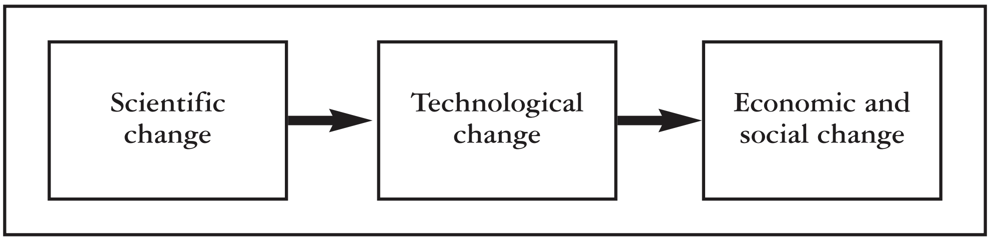
Our field of inquiry can, to a good first approximation, be divided into two major domains. One domain focuses on trying to understand the evolution of technologies and innovation processes, with a view to analysing and improving public policies to support science, technology and innovation. The second domain focuses on trying to understand the role of scientific evidence and expertise in public regulatory policy-making for industrial technologies, and the interactions between science and policy-making, with a view to analysing and improving public policies to regulate and manage technological risks.

Curiously similar patterns of change have emerged in recent years in those two domains. In both domains linear analytical models have been replaced by circular models. The central argument of this paper is that linear models that were oversimplified have been replaced with models that are overly complicated. I will develop the argument by characterising and critically assessing the evolution of analytical models in each of the two domains, starting with the evolution of technologies and innovation processes.

Understandings of technological change

The earliest and most disparaged model of the evolution of industrial technologies is widely referred to as the 'science-push' linear model of change, but it has often also been referred to by historians and social theorists as 'technological determinism'. The essence of technological determinism's linear and uni-directional model was encapsulated in the motto used for the 1933 Chicago World Exhibition, namely: 'Science Finds, Industry Applies, Man Conforms'.[1] Its structure can be represented schematically, as shown in Figure 1.

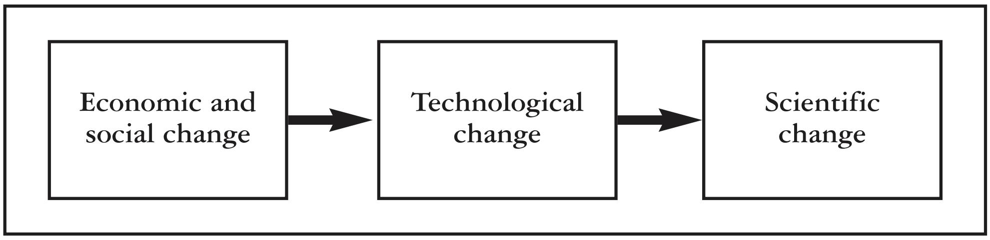
Figure 1. A science-push model



That model has been widely and extensively critiqued (Wyatt 2007). Technology can readily be represented as having a social history and technologies are widely seen as being 'socially constructed' (Bijker 1995; Bijker, Pinch & Hughes 1987; MacKenzie & Wajcman 1999). It is easy to show, for example, that frequently scientific developments do not result in technological changes or industrial innovations, and that social and economic factors can contribute to explaining which technologies are dominant, and which are marginalised. VHS did not displace Betamax as the dominant videotape format because it was technically superior; on the contrary, despite being technically inferior it was more effectively marketed. Scientific and technological changes cannot be understood simply as 'exogenous variables' in economic processes, they are themselves introduced and developed as a result of decisions by organisations and individuals (Rosenberg 1976).

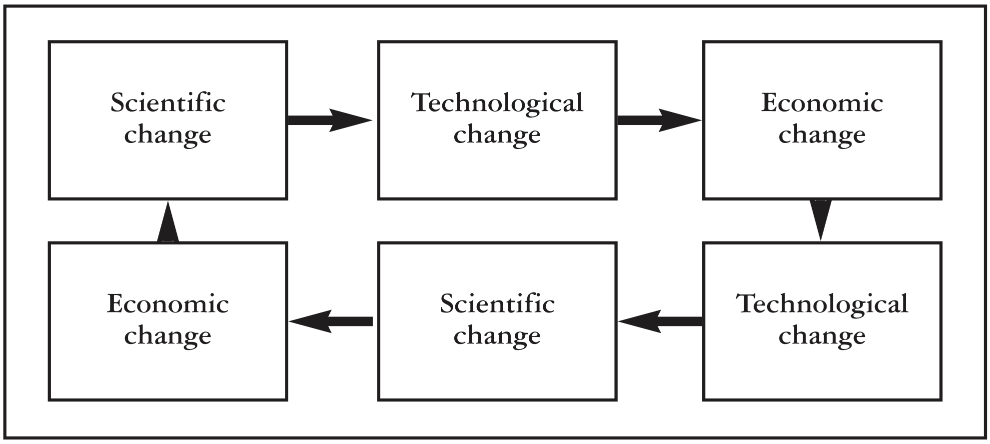
To try to accommodate the role of consumer demand and social change into models of innovation, Schmookler introduced an inverted form of the ‘science-push’ model, which came to be known as the ‘demand-pull’ model of industrial innovation; although that model was also linear and unidirectional (Schmookler 1966). A demand-pull model can also be represented schematically, as shown in Figure 2.

Figure 2. A demand-pull model of industrial innovation



Through multiple empirical studies, evidence accumulated showing that often neither of those two linear models provide adequate resources with which to capture the complexities of historical and contemporary processes. In response, a new school of evolutionary analysis emerged, in which the term ‘co-evolution’ is frequently deployed to emphasise the complex interdependencies between scientific, technological, social, economic and cultural changes. Such models can be represented schematically as in Figure 3.

Figure 3. A co-evolutionary circular model of inter-dependent changes



Such co-evolutionary theories have proliferated in the last 15 years (see e.g. Dosi 1984; Dosi & Orsenigo 1988; Metcalfe & Mansfield 2005; Nelson 1994; Nelson & Winter 1982; Pavitt 1999).

Circular models are problematic

Despite the popularity of such circular co-evolutionary models, they are confronted by several serious generic problems. Firstly, if everything depends on everything else, it suggest that you cannot change anything without changing everything, and there is no way of knowing where to start to achieve effective change.

How far those considerations are thought to be critical depends on one's assumptions about the function and utility of models – it depends on assumptions about what models are for. If they are supposed to capture the rich details of an indefinitely large number of historical examples and to fully highlight their diversity and complexity then such circular multiple-interacting models may be deemed useful, but if they are intended to enable us to distinguish between more and less important aspects of socioeconomic and technological processes then they may not be entirely helpful. As Chris Freeman once explained, a map that captures all the details of the terrain being mapped does not help anyone to navigate through that territory. Maps gain their utility by omitting lots of detail, and by concentrating on salient and important features of the terrain. My argument assumes that we want our models to highlight the difference between more and less important features of the system, and to indicate the main drivers of stability and change. Ultimately perhaps, everything is inter-connected with everything else, but some things are more closely connected than others, and some connections are more direct and important than others.

My main criticisms of the circular model then are, not that historical processes have never conformed to that stereotype, but rather that it fails to adequately differentiate more from less important links and interdependencies. I shall argue that the main drivers of change can be located and distinguished from secondary and tertiary drivers and their effects; but before doing so, I will outline a similar pattern of evolution in the domain of science-based regulatory policy-making and will draw a pertinent lesson from it.

Understandings of science and policy

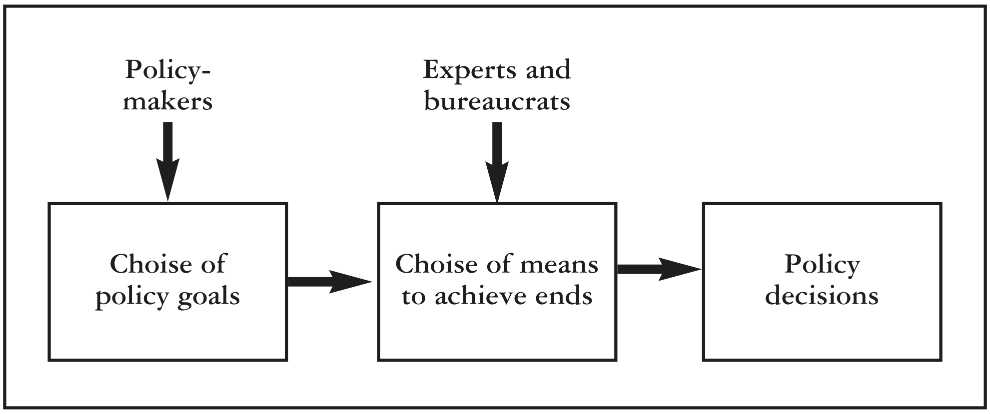
In the 19th century and the first half of the 20th century the role of experts in policy-making was rarely thought of as essential or problematic. Policies were routinely officially represented as emerging from wise rulers, whose wisdom included occasionally seeking advice from relevant experts. Policies were typically legitimated with narratives insisting that all relevant considerations and information had been taken into account – a rhetorical tactic that continues to have some currency.

The Second World War and the post-war crises created conditions in which scientific expertise and policy-makers became entangled as never before (Rose & Rose 1970). During and immediately after that period, the relationship between scientific expertise and public policy-making emerged as a topic of serious attention. Two important intellectual traditions strongly influenced the ways in which science and governance came to be understood, both with their roots in the late 19th century. One tradition can be traced back to the work of Max Weber and Emile Durkheim in Germany.

Weberian / Durkheimian decisionism

Weber and Durkheim argued that modern industrial societies could only function with increasingly bureaucratic forms of governance, requiring new forms of organisation and administration. Weber and Durkheim were not advocating technocracy, but warning against it. To diminish the dangers inherent in governments becoming increasingly reliant on officials and experts, Weber argued that the proper role of bureaucrats should always be a subordinate one. The judgements of bureaucrats (and by extension expert advisors) should always be framed by the policy goals and objectives that should be set by politically accountable representatives, rather than by unaccountable officials. Weber's model of the role of experts in policy-making has come to be known as a 'decisionist' model, because it stipulated that the deliberations and judgements of the bureaucrats should be framed by, and secondary to, prior goal-setting policy decisions. A graphic representation of Weber's decisionist model is given in Figure 4.

Figure 4. A Weberian decisionist model – politics first, then experts



Both Weber and Durkheim argued that policy-making could be made more rational and scientific than it had been, but only partly, not entirely. The decisionist model presupposes a clear and strict division of labour between what Habermas referred to as '(…) the objectively informed and technically schooled general staffs of the bureaucracy (…)' (including the experts) on the one hand and political leaders on the other (Habermas 1971). Weber recognised the superficial attraction of the idea of assigning full responsibility for all aspects of policy-making to bureaucrats and technocrats, but argued that it was unrealistic because policy-making could never be decided solely by the facts since, although the choice of 'means' may be rationalised, the choice amongst the 'ends' and objectives of policy, and the underlying values remain irredeemably subjective (Weber 1958).

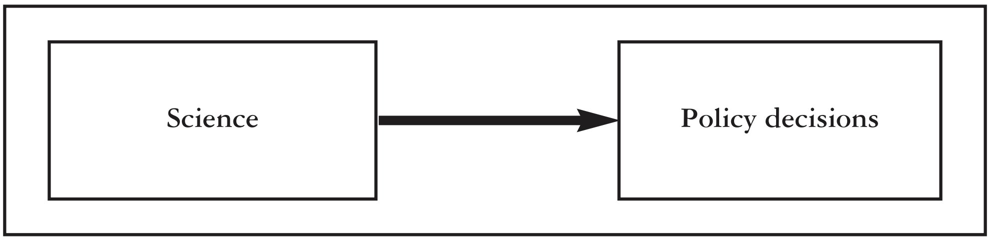
On Weber's decisionist model there were two discrete sets of deliberations, and correspondingly two distinct lines of accountability. Ministers should be responsible to elected representatives for their initial choice of policy goals, and through them to the electorate. Bureaucrats and experts, on the other hand, should be accountable to ministers for effectively pursuing the prior goals set by ministers, and to other experts for the knowledge and judgements that they bring to bear in the discharge of their responsibilities.

Technocratic assumptions

The division of labour envisaged in the decisionist model encountered a key difficulty. In a relatively static pre-industrial society, political goal-setting might be independent of up-to-date scientific knowledge, but in a rapidly changing and technologically dynamic society, those responsible for goal setting may need a great deal of scientific and technical information about the potential benefits and risks arising from new technologies and knowledges. Without that information, policy-makers would not even know which areas of policy to develop. Under those conditions, the division of labour between those that choose the ends of policy and those that select the means for attaining those ends breaks down. If expertise has to contribute to the deliberations on goal-setting, two questions arise: how can experts legitimately perform that role? And: what role remains for non-expert policy-makers?

In France, a competing vision of expertise and policy-making had been developed by Henri de Saint-Simon and Auguste Comte; they were not warning against technocracy but enthusiastically recommending it. Technocratic models became increasingly attractive to governments of industrial nations in the aftermath of the Second World War, as they provided politicians with a narrative that helped them to depoliticise highly controversial policy issues. Saint-Simon, Comte and other advocates of technocracy adopted very optimistic assumptions about the progress, accuracy and adequacy of science and argued that public administration by impartial experts could and should replace governance by those with partial biases, ignorance and vested interests. The technocratic model of policy-making, as it is widely termed, has often been encapsulated in the claim that policy should be based on, and only on ‘sound science’. The conceptual structure of the technocratic model can be represented schematically, as shown in Figure 5.

Figure 5. The technocratic model



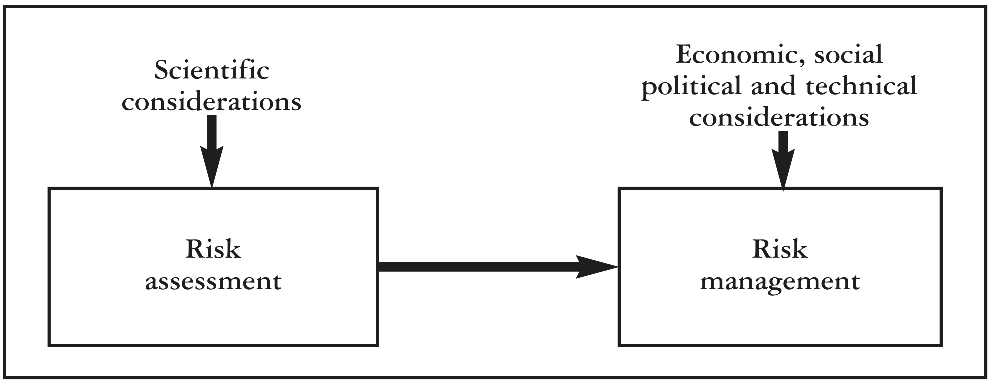
In the USA from the 1950s to the late 1960s, and in much of Europe until the late 1990s, the dominant official narratives were technocratic ones (Brickman et al 1985; Ezrahi 1990; Jasanoff 1990, van Zwanenberg & Millstone 2005). Technocratic narratives presuppose that the science and the relevant facts are entirely objective and socially and politically neutral and that all the facts can readily be gathered. Technocratic rhetoric is therefore potentially very vulnerable to arguments highlighting that the evidential base and the understandings of experts are incomplete, unreliable or equivocal. Scientific uncertainty and disputes amongst the experts undermine the plausibility and credibility of the technocratic model.

While technocratic narratives survived in Europe until the late 1990s, they became unsustainable in the USA during the late 1960s and early 1970s. This occurred firstly because some Congressional legislation acknowledged scientific uncertainties and provided federal agencies such as the US Food and Drug Administration (FDA) with guidance on how they should interpret and respond to such uncertainties.[2] Secondly, Congress introduced a Freedom of Information regime, which entailed the disclosure of sufficient information on the science used to support policy to reveal that the science was often profoundly uncertain. Consequently the USA had to develop an alternative to the technocratic model in the 1970s, whereas European countries and the European Commission were only obliged to make similar shifts in the late 1990s and early years of this decade. The BSE saga and crises in the UK and EU torpedoed technocratic narratives below the waterline.

The US authorities developed an innovative model of the role of science in risk policy-making, using a new vocabulary. Science-based risk appraisal and decision-making was portrayed as a two-stage process, the first of which came to be referred to as 'risk assessment' and the second of which is known as 'risk management'. The first of those two stages was portrayed as a purely scientific one and the second as a policy-making stage at which non-scientific and often normative considerations, such as economic, social and political factors should be taken into account. On this two-stage model, policy-makers (or 'risk managers') are informed and influenced by scientific advisors, but the scientific advisory bodies are portrayed as entirely independent of policy, and of any and all non-scientific considerations. Scientific advice was, and often still is, portrayed as emerging from a socially, politically and economically neutral space. A curious feature of this model is that it resembles the Weberian decisionist model, with two similar stages, one political and one technical, but with the sequence inverted.

This model was endorsed in a report from the US National Research Council (NRC) called *Risk Assessment in the Federal Government: Managing the Process* (US NRC 1983). In what came to be known as the 'Red Book' (given the colour of its cover), the NRC panel has been widely interpreted as asserting that science-based risk policy-making can and should be entirely legitimate, but only if it is conducted in ways that ensure a proper separation of science from policy in precisely the same way as had been envisaged in the science-first (or inverted) version of decisionism. The model is not just linear but also uni-directional, and its structure can be represented schematically, as shown in Figure 6.

Figure 6. The 'Red Book' inverted decisionist model



This model, often supplemented with a third stage called 'risk communication', has been adopted by almost all of the most powerful policy-making institutions; it became the new orthodoxy in the 1990s when it spread from the USA to multilateral bodies such as the OECD, the European Union and the Codex Alimentarius Commission which, under the rules of the World Trade Organisation, sets global baseline standards for all internationally traded food and agricultural products, and also to numerous individual EU Member States.

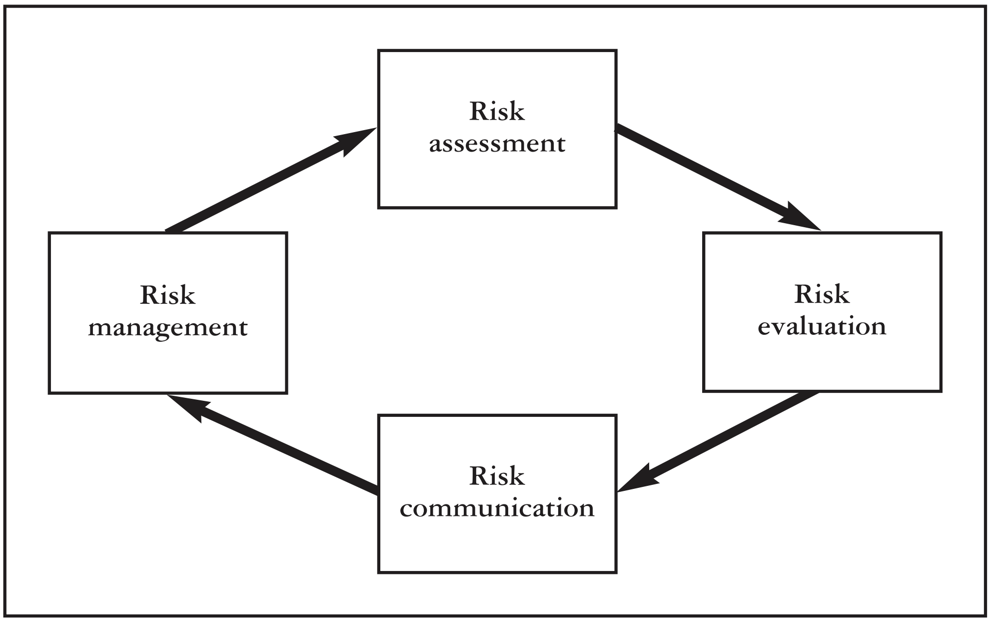
Co-evolutionary models

Despite its official popularity, science policy analysts and sociologists of scientific knowledge have long been critical of the Red Book model, and for two main reasons. Firstly it presupposes that the available scientific knowledge is reliable and known (or knowable) with sufficient certainty, and that experts can readily reach a consensus. In practice, the available science is frequently incomplete, uncertain and equivocal, and the scientific community rarely speaks with one voice. In practice, therefore, it will always be possible to provide multiple risk assessments that are equally scientific even though they diverge and can even contradict each other. In those circumstances, scientific risk assessments cannot determine the goals of policy, and policy-makers' responsibilities cannot be confined to selecting the preferred means to reach the predetermined ends.

Secondly, it presupposes that scientific risk assessments can be, and routinely are, developed in socially, politically and ethically neutral settings, and that scientific risk assessments can be and are constructed solely from scientific considerations. Numerous scholars have documented some of the most important ways in which social, economic, political and cultural considerations have influenced the agendas, deliberations and conclusions of official scientific advice on risk issues (Levidow et al 1997; Jasanoff & Wynne 1998; Millstone et al 1999; Abraham 1993; Castleman & Ziem 1998; van Zwanenberg & Millstone 2000; Huff 2002).

Jasanoff has been right to emphasise while: '(…) pleas for maintaining a strict separation between science and politics continue to run like a leitmotif through the policy literature, the artificiality of this (...) can no longer be doubted. Studies of scientific advisors leave in tatters the notion that it is possible, in practice, to restrict the advisory process to technical issues or that the subjective values of scientists are irrelevant to decision-making' (Jasanoff 1990). Accepting that premise entails abandoning both the technocratic and Red Book models. One influential set of responses has been to develop and introduce a 'co-evolutionary' circular model of science in policy-making, which can be represented schematically, as shown in Figure 7.

Figure 7. A circular co-evolutionary model of science in policy-making

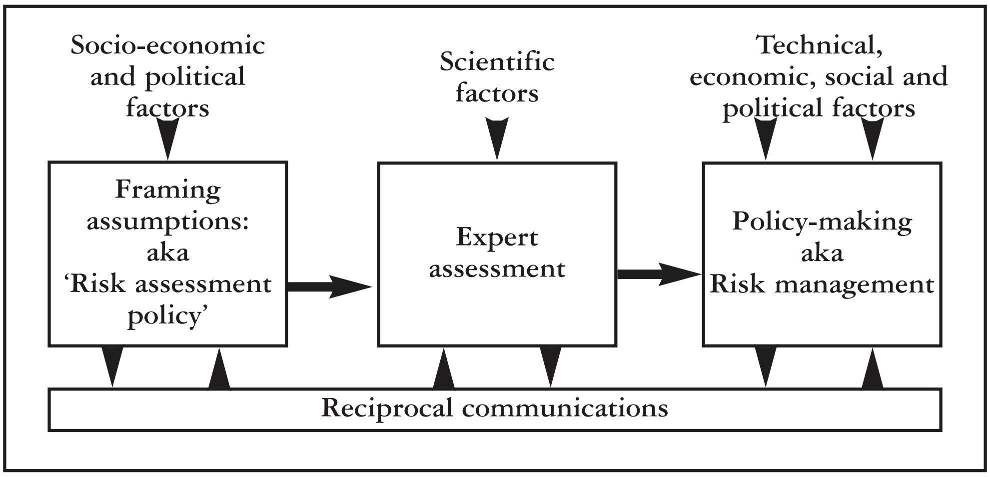


Models of that sort can, for example, be found in documents published by the International Risk Governance Council, and by the UN Food and Agriculture Organisation (IRGC 2006; FAO 2006). Despite their popularity with both scholars and some parts of the wider policy-making community, those circular models are confronted by the same challenge as all such circular multi-part models – can nothing be changed without changing everything, and where can you start to trace influence and make change? They are also often represented as closed cycles, suggesting that there are no entry points for external contributions. I have yet to encounter any attempt to explicitly address those challenges, and I have yet to encounter circular models that provide the resources with which those challenges could be met.

To avoid those difficulties, and to highlight that some factors and judgements are more important and influential than others, I prefer a new variant of old-fashioned linear models, only this time the model differs in two key respects. Firstly the model has a clear starting point, but that starting point is not a set of scientific facts or technological artefacts, or novel niche markets for innovative products and services, but a set of normative judgements about what is important, and which aims and objectives to pursue. Secondly, although linear, it is characterised nonetheless by reciprocal interactions so that it is not uni-directional but bi-directional.

I propose to call this model, a co-dynamic 'transparent' model, and its structure can be represented schematically, as shown in Figure 8.

Figure 8. A co-dynamic 'transparent' model



This model acknowledges that science-based risk policy-making depends on both expert scientific assessments and on a rich set of non-scientific considerations, but instead of portraying risk assessment as if it occurred in a policy-free space, the model represents those scientific deliberations as 'sandwiched between' a set of up-stream judgements that provide key assumptions about what is to be assessed and the questions to which answers are expected on the one hand, and on the other a set of downstream evaluative judgements about what actions are appropriate in the light of those answers and other considerations about what alternative courses of action are available, how they might affect differing groups, how much they might cost and how acceptable they might be.

To the extent that this model starts, on the left-hand end of the main axis, with a set of normative judgements about what is important and about aims and objectives, this model is similar to those of Weber and Durkheim in that it is 'teleological', i.e. goal oriented rather than fact-based. It is a linear, rather than a circular model, but it is reciprocal rather than uni-directional.

An important consideration at this stage is to note that, even though this model has been developed in the context of debates about the appraisal and management of risks, it can be adapted, with only a minor modification, to represent processes to appraise not just the risks but also the benefits of technologies; consequently the concept of a 'benefit assessment policy' may usefully be deployed. It may therefore also serve as the basis for a more general model of drivers and appraisals of technological changes, and key aspects of their relationships with scientific and economic changes.

Teleological models are, *prima facie*, appropriate in both of those sets of contexts because data do not collect themselves, experiments do not design and conduct themselves, artefacts do not design, manufacture or market themselves; all those processes are intentional and goal-oriented, though the goals themselves may vary markedly. The model therefore may provide an architectonic structural basis for models of both technological change and regulatory policy-making.

Co-dynamic models in practice

While co-dynamic models were developed initially by scholars and policy analysts in the 20th century, they have been adopted by public policy makers in the early years of the 21st century, sometimes explicitly and at other implicitly. These crucial developments have taken place primarily in the domain of food safety policy-making, in the aftermath of the BSE crisis that started in 1996, and the GM crops disputes that followed a few years later.

The official governance institution that has done most to acknowledge the existence and importance of up-stream framing assumptions is the Codex Alimentarius Commission, which was established in 1963 at the joint initiative of the UN FAO and the WHO. Codex sets standards for internationally traded agricultural and food products, and prior to the establishment of the World Trade Organisation, Codex was relatively unimportant because the status of its standards was only advisory, but since 1994, and under the provisions of the Sanitary and Phytosanitary Agreement, Codex standards set minimum benchmark standards for internationally traded foodstuffs. WTO Member States can refuse to accept products that fall below Codex standards, but they cannot refuse to accept products that meet Codex standards unless they have established, by a legitimate process, standards based on a scientific risk assessment; otherwise they may provoke and lose a trade dispute at the WTO.

In the early years of this century, and in the face of a growing chorus of criticism (Avery & Lang 1992; Huff 2002; Watterson 1993) Codex endeavoured to ensure that its procedures and processes were robust and legitimate. At the initiative of the Codex Committee on General Principles, Codex introduced a new concept, namely ‘risk assessment policy’ that can be understood as an explicit recognition that science-based risk assessments are routinely framed by a set of prior up-stream non-scientific assumptions about what is, and is not, important and which factors and bodies of evidence need to be taken into consideration.

Since 2003, the *Procedural Manual of the Codex Alimentarius Commission* has stipulated that:

> Determination of *risk assessment policy* should be included as *a specific component of risk management. Risk assessment policy should be established by risk managers in advance of risk assessment, in consultation with risk assessors and all other interested parties.* This procedure aims at ensuring that the risk assessment is systematic, complete, unbiased and transparent. The mandate given by risk managers to risk assessors should be as clear as possible. (Codex 2003, Appendix IV, paras. 13–16)

Important features of those provisions include the recognition that risk assessment policy (or RAP) is prior to the deliberations of risk assessors, so that scientific risk assessments need to be *explicitly* framed by prior policy and management considerations. Those explicit RAP framings should, moreover, be established by risk managers in consultation with all interested parties, including the risk assessors. In other words, while scientists may have a contribution to make to those deliberations, so too may all other parties such as consumers and their representatives, public health professionals as well as industrial and commercial organisations.

In a study published in 2004, Millstone et al. showed that various national official risk assessments of particular technologies often conflict, and not just because of differing interpretations of agreed bodies of evidence; more often different conclusions arise because different groups of experts are answering different questions and taking account of different bodies of evidence (Millstone et al. 2004). That shows that risk assessment policies are a key policy variable, account for the emergence of many risk-related trade disputes, and indicate furthermore some of the conditions under which such disputes might be avoided or resolved.

More recently, in July 2007, all Member States of Codex, including all EU Member States, and the European Commission as a member of Codex and a legal jurisdiction, accepted matching provisions whereby all of their risk managers would provide their risk assessors with RAP guidance. In other words, the co-dynamic model has in effect been adopted, at least in respect of food safety policy-making by all members of the UN FAO and the WHO, which corresponds to virtually all public authorities on earth.

In a further recently published study, evidence emerged to show that in a wide range of institutional settings, i.e. UK, Germany, USA, Japan, Argentina and Codex, at least some RAP guidance was being provided by risk managers to risk assessors (Millstone et al. 2008). That study also concluded that there are at least three main types of RAP considerations, namely substantive, procedural and interpretative issues.

Substantive RAPs are concerned with delineating which potential changes and effects are to be included within the scope of risk assessments and which are outside their scope, and which kinds of evidence are admissible and which are not. *Procedural* RAPs are concerned with the processes by which risk assessments are conducted and reported. For example, should risk assessment deliberations be conducted in open or closed meetings, and how should risk assessors respond to uncertainties? *Interpretative* RAPs are concerned with the ways in which data are interpreted. Data and documents do not interpret themselves; interpretation often involves judgements and assumptions which count as components of RAPs.

To the extent that regulatory bodies publish documents specifying minimum data requirements for their reviews and risk assessments, they are providing some substantive RAP guidance, and many do. Minimum data requirements indicate the kinds of risks that, at minimum, should be taken into account, although they do not necessarily specify the full range of effects that might be deemed relevant. Rules about whether expert risk assessors meet in public or in closed sessions, and whether or not they should only report consensual agreements or whether differences of views need to be reported can be counted as parts of procedural RAP. Guidance as to how much of which kinds of data might be variously necessary or sufficient for categorising a compound as 'safe' or as e.g. a carcinogen counts as part of interpretative RAP. However there is little or no evidence of consistency within risk topics when comparing across jurisdictions and institutional settings, or within jurisdictions when comparing across risk topics.

In none of the institutional settings or risk topics included in that study were all three types of RAPs dealt with explicitly by risk managers, as stipulated by the Codex rules and agreement, but in every jurisdiction at least some types of RAP issues were dealt with explicitly by risk managers, though many are in effect being decided (explicitly or implicitly) by risk assessors, who have consequently been making policy judgements that have masqueraded as if they were purely scientific.

At the time of writing, in summer 2008, we are witnessing the early stages of a process in which the co-dynamic model is increasingly being recognised and adopted by policy-makers as well as by scholars and policy analysts, and that may well transform the ways in which food safety policies are deliberated and decided. Moreover the template that has emerged in this field may well be disseminated and reproduced in other science-based risk policy-making fields, and thereby create the conditions in which risk policy-making more generally might become more legitimate both scientifically and democratically (Millstone 2007).

Summary and conclusion

Since I have argued that up-stream normative considerations play a critical role in both innovation and regulatory policy-making – dealing with both benefits and risks – it follows that analogous linear but bi-directional models can illuminate both fields, and that both sets of policy judgements can be seen to be grounded in normative goal-oriented considerations rather than in technical or scientific facts. Such bi-directional linear models have the advantage over circular models that they do indicate that some factors are more important and influential than others, and where to start when trying to bring about desirable changes. Furthermore those models can serve both analytical purposes and normative functions, and avoid the dangers of circularity.

Notes

[1] http://www.encyclopedia.chicagohistory.org/pages/225.html

[2] See 1958 Food Additive Amendments to the 1938 Federal Food, Drug and Cosmetic Act

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