

Paradoxes and the Future of Safety in the Global Knowledge Economy

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Abstract

Governments face increasingly acute dilemmas in securing the safety of their citizens in the face of controversial technological innovations. This state of crisis results from structural features of the global knowledge economy. Governments are forced into contradictory roles, acting both as promoters of global business enterprise and also as regulators on behalf of a sophisticated and suspicious public. I explain the crisis by substituting 'safety' for 'risk' as the operative concept, and also using paradox as an explanatory tool. I produce a closed-cycle paradox, analogous to the classic Catch-22, to exhibit the contradictions in the situation. I argue that 'safety' is a very useful concept for policy-related science precisely because it exposes those contradictions and others latent in scientific methodology. I discuss ways of resolving these contradictions, which include the recognition of policy-critical ignorance and the adoption of the perspective of post-normal science.

Keywords:

Safety, Paradox, Contradiction, Policy-critical ignorance, Post-Normal Science,

Introduction

As the conditions of life have improved in comfort, convenience and safety for at least the rich minority in the world, governments have increasingly accepted the responsibility of assuring safety of their citizens. But now this function is in a state of crisis. This relates to the dilemmas now encountered by governments. They face contradictory demands, when on the one side global business in the knowledge sector requires support for innovation, and on the other side citizens, aggrieved and sometimes militant, locally and in affected regions, demand safety.

These sorts of policy dilemmas are well illustrated by the decision of the UK government to embark on farm-scale testing of GM (genetically modified) crops in mid-2000. These trials were necessary for their arguments against GM to be heard in the relevant forums. For without data on possible hazards, the UK would not be able to put a case to the World Trade Organization for restricting an agricultural use of GM. This would be necessary, in the event of some other country making a complaint about UK policy. And if the WTO did not support the UK policy, the continuation of a restriction could put the UK government in breach of its treaty obligations. We are thus in the paradoxical position where these field tests, which some have argued are potentially dangerous in themselves, were necessary if the UK government were to be allowed by an international organisation to guarantee the safety of this branch of agriculture.

The paradoxes could become worse confounded. For it is possible that (in the event of a complaint) the three-man committee of the WTO, meeting in secret without appeal, could decide that there is insufficient evidence of risk in the large-scale use of GM seeds, to justify any interference with Free Trade. The UK government would then be required by its international treaty obligations to give its approval, regardless of domestic public opinion on the matter. This could give rise to another set of policy dilemmas, even more serious.

Since GM crops are quite likely to be followed by other contentious issues, be they nano-technology, Xeno-transplants, the expropriation of human genes by patenting, private-enterprise eugenic engineering, or the victimisation of those with 'defective' genes, an understanding of these problems of governance and safety is urgent. For neither good will by itself, nor marginal improvements in 'participation', can be relied on to resolve the genuine conflicts of perception and interest. Nor can they eliminate the structural features of the modern global system of production, which give rise to such disputes and to the consequent dilemmas for governance. The situation is truly paradoxical, and we will use the device of rhetorical paradoxes in order to shed light on it.

Background: modern industry and 'risks'

We might start the analysis by seeing how we got here. Nearly ten years ago our predicament was analysed as 'risk society' in the seminal work by Ulrich Beck.¹ He showed how there are new sorts of dangers, those of 'modernisation', which are elusive and potentially catastrophic. The natural response of regulators is to try to control them by conceiving them in the most narrowly scientific terms; in this way regulators retain their legitimacy while allowing technology to proceed. In response, science itself becomes 'reflexive', and with this new awareness the supposedly 'scientific' facts about risks are relativised to being 'nothing but answers to questions that could have been asked differently'. Then the focus in public debate shifts from the supposed 'facts' to the framing of the risks problems for investigation.² In his original work, Beck expected there to be a continued separation of functions, where the scientists would do the 'reflexive' science and the activists would do the 'sub-politics'.

In the subsequent decade, the potential crises of 'the risk society' became actual, and Beck's separation of functions no longer held. The attempts at a monopoly of the experts in the management of risks problems failed signally in the case of the Brent Spar oil platform in the North Sea, failed catastrophically in the case of BSE/CJD in Britain, and was politically and commercially counterproductive in the case of GM seeds imported into Europe. In all those cases scientists outside the establishment made criticisms, which were not heeded until late, sometimes (as in the case of BSE) tragically too late. Also, the 'sub-politics' of direct action has developed its own counter-science, which is now admitted into the official dialogue as a legitimate voice.

In addition, what is perceived as the 'withdrawal of trust' is actually a rational response by a public whose demands for safety, encouraged for decades as part of the programme of modernisation, are apparently being frustrated and betrayed by the further developments of that same process. The question is now being raised, first in connection with Information Technology³ but easily generalised, whether our technology is actually in a runaway state, out of control. Under these circumstances the State, necessarily acting both as promoter and as regulator, will be confronted by ever more destructive contradictions. This present essay is an introduction to the study of this new syndrome of governance, using paradoxes as a technique of analysis.

For understanding these new contradictions, we must go beyond the political level of analysis, and consider the state of modern business. Its leading sector is commonly understood to be 'the knowledge economy', where the leading industries are involved in 'information technology'. This consists of the manipulations of information, comprising both biological and electronic information, the latter including data, information and images. Transformations of matter and energy, the foundations of earlier industrial epoches, are now subsidiary. This new industrial base both enables and feeds on the organisational processes of globalisation. The problems it creates are not merely a matter of scale. After the recent episodes of protest, even the proponents of the World

Trade Organisation admit the need to answer the charge that globalisation involves the harnessing of all resources, material, social and cultural, on a planetary scale, for maximum private-corporate profit.

Long ago Karl Marx pointed out that capitalism depends on, and hence fosters, the constant revolutionising of the means of production. It was a great historical irony that under the system which he expected to be the successor of capitalism, the means of production eventually regressed! But under contemporary capitalism, the pace of innovation does really accelerate, for firms now depend on constant innovation for maintenance of market share and hence for their corporate survival. This pressure is most intense on firms in the advanced sector; in the more traditional, slowly-changing industries, firms find it easier to show care for safety and the environment.

In the case of the leading-edge industries, there arises an inevitable conflict between innovation and safety. For the risks of modernisation as defined by Beck are extremely difficult, if not impossible, to assess and then manage along traditional scientific lines. Many of them are, in John Adams' terms, 'virtual'.⁴ Who could have imagined that molecules of those artificial chlorine compounds, specifically designed to be inert, would drift up to the stratosphere and be chemically combined there, leading to the Ozone Holes? Even earlier, who could have imagined that a very useful drug, DES, would after a twenty-year lag, cause vaginal cancers in the daughters of women who had been prescribed it in order to stabilise their pregnancies? Given our great uncertainties, even ignorance, concerning the special physiological processes whereby special viruses induce foreign genes to be 'expressed' in plants, who could guarantee the safety of all GM crops for the environment and the human food chain? Who could devise the tests whereby such safety could be assured; and indeed who could guarantee the safety of the farm-scale crop tests themselves?

As technology becomes more sophisticated in its manipulations of information, both biological and electronic, the possibilities for unexpected effects ramify beyond control. Unlike matter and energy, living information can replicate itself, can spread on a variety of carriers, take a variety of pathways, and eventually transform its forms and its actions. How could such an uncontrolled diffusion be prevented? For example, Xeno-transplants can save many lives now; but they might introduce diseases that might after some lengthy period become uncontrollable epidemics. How could their safety be assured? Can we be sure of the functions of all the sequences on the genomes of pigs, however specially bred and cloned, so that they are safe from infectious retroviruses? Again, how could we test, in a manner that is reliable, ethical and safe, for the presence or absence of slow-acting but eventually lethal retroviruses?

Such questions about safety may seem paradoxical, and they are. They also serve as a useful introduction to the contradictions at the root of safety policy in the global knowledge economy. Further, they highlight the rupture with the classical image of

science as essentially positive, promoting humanity's wellbeing through its applications. For here we have science-based innovations affected by policy-critical ignorance about their dangers. And our attempts at a scientific assessment those dangers, necessary for assuring safety, are themselves fraught with their own areas of danger and ignorance.

New challenges in the management of uncertainty, ignorance and danger.

These examples show how far we have come from the simple traditional model of science advancing knowledge for its own sake, and then through its applications being essentially of benefit to humanity. Now we find that science-based innovations bring new uncertainties and dangers along with their expected benefits. Worse, the attempts to assess those negative features by the use of more science becomes controversial, inconclusive, and perhaps even dangerous itself! In assessing plans for the introduction and diffusion of new technologies, along with intended functions and uses it is now essential to take account of possible misuse (accidental), abuse (malevolent) and dysfunction (adversely affecting its various contexts). None of these issues can be conclusively settled by research; all will involve debate. Scientists with the relevant expertise will make their unique contribution to the debate; but they will be complemented by others with equally legitimate perspectives and commitments. And issues of methodology, once safely left to philosophers, are now at the forefront of debate.

As an example of this new methodological awareness, we now know that prior assumptions can determine the outcome even of an inquiry which uses the full panoply of scientific and statistical methods. And such assumptions derive from the policy setting of the inquiry, itself in part at least a politically driven choice. Thus, if 'absence of evidence of harm' is taken as equivalent to 'evidence of absence of harm', then a conclusion of 'no harm' is most likely. If 'merely anecdotal' stories of harm are disregarded, then there is unlikely to be an incentive for investing resources in a scientific study. The discounted 'anecdotal evidence' will remain as our only warning of danger, at least until such time as a major disaster occurs. In such circumstances, the plausible demand for a 'sound science' that bears the pedigree of traditional laboratory research is a diversion from the real issue. It amounts to a throwing of the burden of proof onto those who do not wholeheartedly embrace innovation and who instead advocate precaution in the face of unknown dangers.

The management of 'outlier' data, which to some degree are common in all scientific practice, presents very special pitfalls and challenges. For the acceptance of such data depends strongly on the scientist's judgement of what is significant and what is merely anomalous. The story of the automatic rejection of data indicating an Ozone Hole over the Antarctic is well known. When combined with the general prejudice against publication of negative results, the consequences of ignoring such outlier data can be quite literally lethal. Thus the medical world (and their patients) remained in ignorance

for some thirteen years of the scores of thousands of deaths caused annually by a heart-disease drug, because the increased death rate in the 'treatment' group in a randomised trial had been judged by the authors to be merely a statistical artifact.⁵ (I am indebted to David Waltner-Toews for this example). Even in the most routine scientific research the statistical tests by which raw data is converted to scientific information depend on a parameter called 'confidence limit'. This expresses (however implicitly) the balance of costs and benefits between the errors of over-inclusiveness (excess sensitivity) and those of over-exclusiveness (excess selectivity) in the acceptance of a correlation. Thus ordinary scientific practice is conditioned at its very root by the value-loading in the management of uncertainty .

As the elements of uncertainty and ignorance in the study of a hazard become greater, the more influential will be the prior methodological commitments, and more remote is the possibility that 'normal science' will provide the 'facts' that establish the level of risk. We have actually been living with such a situation for decades; the distinguished nuclear engineer Alvin Weinberg coined the term 'trans-science' for problems that can be expressed scientifically but not solved scientifically.⁶ His example was the proposed standard for radiation exposure in the neighbourhood of civil nuclear facilities. One percent of natural background seemed a plausible maximum level; but then it was estimated that to establish whether significant effects were present at that level would require some eight billion rats! If such a linear and straightforward pollutant as ionising radiation can produce such strictly impossible requirements, what can we say of those involving the possible flows and the expressions (immediate and also delayed) of genes in humans and in ecosystems?

With the erosion of the previous naive certainties about scientific facts, based on the traditional experience of the laboratory and mathematical science, some fear that the whole enterprise is going 'post-modern'. That is taken to mean that 'anything goes', and rationality and dialogue are swept aside by naked power-politics, a conflict between brutal vested interests and unscrupulous demagogues. But there are other possible interpretations of our predicament. It is possible to extend the traditional procedures of scientific assessment to meet these new conditions. In this new perspective, we see that in traditional research, uncertainties are normally managed at the technical level (by statistical techniques). Values are also unproblematic, being either external to the research activity, as in the choice of priorities for problems, or implicit as in the setting of confidence limits for statistical tests. But there are other science-based activities where both elements must be managed explicitly; we call these 'professional consultancy' (as the surgeon or the senior engineer) where the uncertainties presented by Nature cannot be totally tamed, and where values (notably, the possible loss of life resulting from an error) are always present. This sort of problem-solving activity has a different clientele, and different means of quality-assurance, from those of traditional science.

If we now extend our view to the case where both uncertainties and value-loadings are high, then we need yet another form of practice. We call this 'post-normal science'.⁷ It can be said to become relevant when 'facts are uncertain, values in dispute, stakes high and decisions urgent'. In this case, we need an 'extended peer community' consisting of all those concerned with an issue; and they must be able to offer their 'extended facts', including (for example) community based research, local knowledges, anecdotes, unofficially obtained official information, along with their personal and communal value commitments. This sort of process is now usually described as 'openness' or 'participation'; it is now generally accepted that attempts to reduce complex policy problems to their purely technical dimension have failed and will continue to fail. But with the concepts of post-normal science we can see why this new approach is necessary and also how it can be successful.

A new polity engages with risks

Such developments in the polity, and its increasing engagement in the politics of science, are fostered by the very processes that have made them necessary. The ever-changing production processes of information technology require sophistication, both in their scientific basis and in a reflective practice. At least in the advanced nations, the traditional semi-literate work force is shrinking in relation to those with technical sophistication and some degree of general literacy. These new workers are subjected to contradictory tendencies. On the one hand they are increasingly fed the cultural pap of mass entertainment, made all the more addictive by the electronic technology of spectacle. But on the other hand they are getting the basic equipment for reading and thinking independently when issues affect them. It is likely that national and regional cultural traditions will determine which tendency becomes uppermost in any particular place. Even now, the occasional mass boycotts of suspect foods, and the steady move to 'organic' foods in Europe, cannot be reduced to a simple effect of panic-mongering by media and pressure-groups. They reflect a new citizens' critical awareness among groups of people who had previously been dismissed as mere 'consumers'.

The increasing involvement of lay persons in policy processes is a reflection of this new mood among the public, and of the response of far-sighted governments to its challenge. But such increases in participation do not necessarily result in a simple restoration of trust. As the public becomes more sophisticated about such issues, it can become even more suspicious of government assurances of safety. It was a truly exquisite irony that Monsanto itself commissioned the research which showed that official reassurances actually decreased British public acceptance of new products.⁸ Hence the great increase in 'trust' in environmental organisations, as reported in opinion polls, is doubtless not an implicit trust in their veracity, but rather a sense that they are on 'our' side and not 'theirs'.

The public's growing rejection of the official version of reality is also reflected in the rise of sophisticated 'alternatives', which cannot be either destroyed or totally tamed. These will include from activist counter-movements, using mass-media spectacle for non-violent coercion. But equally significant are the large-scale defections from the official scientific system, as in diet and healthcare, and also the diffusion of enhanced personal cosmologies. These last sorts of actions are usually not self-consciously radical or subversive; after all, anyone can get an aromatherapy treatment, and in England the oriental 'science' of Feng Shui is positively chic. But as they become widespread, such practices amount to the social construction of new realities, with a new common-sense, in which the strident warnings and denials of the official scientific system are simply ignored. All these developments are focussed on special issues; there is no sign of 'alternatives' being used as a challenge to Science in the way that Science had been used in the past as a symbol in the challenge to Religion.

But in the long run there must be an effect on the authority of Science as a foundation of legitimacy of the modern state. Previously accepted as an independent source of knowledge as well as of public benefits, it is now increasingly seen in another guise as an instrument of corporate profit and of unaccountable power. And with the rise of 'alternatives' its authority over the conduct of ordinary life diminishes as well. It is impossible just now to predict the future politics of safety; but these multiple tendencies to the loss of legitimacy of official scientific expertise are there now, and will certainly increase.

We therefore face a truly unprecedented challenge. Our science and technology have, over the generations, seemed to conquer uncertainty and ignorance in one field after another, providing us with ever increasing safety. Yet now we find ignorance returning with a vengeance, and in roles where it is relevant and indeed crucial. Our previous scientific methods, designed around the achievement of positive knowledge and the fostering of ignorance of our ignorance, will need to be modified and enriched.⁹ By focussing on the paradoxical nature of our predicament, this present essay is intended to contribute to this new learning process.

A re-conceptualisation: safety.

In order to learn new ways of thinking, we must first make a critical examination of the old. The term 'risk', now controlled by official expertise, stands in the way of learning. For it reflects a reductionist conception of the phenomena and hence of the policy problem. First we use natural-scientists to estimate the probability of an event, and social-scientists to estimate its harm. Then by compounding the two estimates we get a number for directing policy choices. What is ironed out of this scheme is all the complexity, social, ethical and conceptual, of the process whereby unwanted events first happen and are then managed.

By contrast, 'Safety' and 'danger' are the older terms, relating directly to human experience. But with the triumph of scientific expertise, they have fallen into disuse in the policy discourse. Thus the concept 'safety' or 'safe' is, by contrast, seen as 'relative and subjective', even by the authors of the House of Lords report on trust in science¹⁰. The presuppositions of the authors, providing good evidence for the prevailing mindset, are displayed by the statement that the difficulties in the question, 'is it safe?' could be reduced if 'the public has some concept of scientific methods.'

Certainly, if 'safety' is seen as the same sort of attribute as 'risk', then in comparison it will indeed be vague and subjective. But that is to miss the richness in the concept, and hence to overlook its importance for our understanding of the present dilemmas. We may look at 'safety' in two ways. First, we can think of 'The Safe' as a new addition to the set of absolutes defining the quality of human existence. The traditional ones can be given as: the True, the Good, the Just, the Holy and the Beautiful. Nothing in this world is perfectly true, or good, etc. But there are ideals out there, by which we assess, argue about, and redefine our beliefs and practices in those dimensions. Each of them, as realised in a particular culture, is historically conditioned, with differences between various conceptualisations and with contradictions within each. But as elements of our consciousness, they are nonetheless real and important.

It is of great historic importance that within the last few generations, the possibility has arisen that people can really be safe. That sort of aspiration is conveyed by the ideal of 'Four Freedoms' announced during World War II by Franklin D. Roosevelt, as freedom of speech and expression, freedom of worship, freedom from want and freedom from fear. Of course, it is impossible to achieve perfect safety, any more than perfect justice; and to assess the degree of safety in any given situation may be at least as tortuous as to assess the degree of justice. Philosophers could argue that there is nothing in 'The Safe' beyond a collection of socially constructed images. But as an operative ideal, 'the safe' is definitely implanted in modern society. The great paradox of this current brief period in human history is that the very technology that first made 'safety' possible, then expected and finally demanded, is now becoming seen as the cause of that same safety becoming increasingly compromised.

The other way to understand 'safety' is in terms of what sort of attribute it is. It is not a mere descriptor of a situation. Rather, it is fundamentally a pragmatic attribute, with a moral dimension. Some say that when the public demands 'safety' they want an impossible 'zero risk', but with that opinion they merely betray their own ignorance of the human condition. A situation or action is 'safe' when it is 'all right' to be somewhere or to do something. A place or action is safe when we believe that those who are in control of the situation (or the context of the action) are trustworthy and competent. Thus mass passenger travel on commercial airlines had been deemed 'safe' in spite of frequent fatal accidents; but after 9-11 in America at least there is a sense of danger. Not all airlines are equally 'safe'; some are positively 'dangerous'. The book by Perrow on

'normal accidents'¹¹ was subversive because it showed how some managements will 'normally' create situations where operatives must regularly 'take chances', or else lose their jobs. In those cases what is announced as 'safe' turns out to depend on luck for its continued accident-free operation. The management has betrayed a trust, thereby violating a duty of care to those depending on it. That is the meaning of 'unsafe' practices, or of a 'dangerous' situation.

My use of 'safe' is not at all idiosyncratic. Although the relevant regulatory agencies employ scientists as risk analysts, for the description of their protective functions their titles include 'health' and 'safety' (in that order for the British 'Health & Safety Executive' and with terms reversed for the American 'Occupational Safety & Health Agency'). It should be mentioned that 'health' is an even more challenging concept than 'safety', since our culture cannot comprehend a 'healthy dying', while in spite of our drive for health we know that death awaits us all.

Another aspect of safety, that might seem quite irrational for those who conceive it on a scientific analogy, is that in the total, synthetic judgment it also includes personal benefit. It has long been observed that people will generally incur voluntary, lifestyle risks that are out of all proportion to those against which environmentalists declaim; smoking is the classic example, with alcohol and fast driving not far behind. It would be a ludicrous caricature to call this an 'implicit cost-benefit calculation', since such decisions may rest on a refusal to accept plain and decisive quantifications of the risks. Rather, a feeling of 'safety' may depend so strongly on a sense of personal wellbeing, that it will enable a totally anti-scientific policy, as well as a self-destructive lifestyle, to be followed. At that extreme, 'safety' is indeed a largely subjective attribute, although it is a subjectivity that is reinforced by the surrounding commercial culture at every point (see the mass advertising that promotes both drinking and fast driving separately, when their conjunction is so lethal). In current policy terms, this inclusion of perceived benefit explains why the European public generally is so suspicious of novel foods, while (as yet) showing little resistance to experimental, speculative advances in medical and reproduction technologies.

With this understanding of 'safety', we can move beyond the exasperation that those in positions of responsibility frequently have with an apparently 'irrational' public. Those who have engaged in serious dialogue with ordinary citizens discovered that they can be quite sophisticated in their understanding of the politics of risks and uncertainty, and quite mature in their appreciation of what is possible in the way of achievement of some degree of safety for them^{12 13}. This evidence enables us to see that public trust will not necessarily be restored by an improvement in some communication practices, or by cosmetic reforms to the total technical-political system in which safety is seen to be compromised. And since so much of the legitimacy of the modern state depends on its delivery of safety (as opposed to the traditional justifications by divinity, birth or wealth), a failure with safety can have severe consequences for governance as a whole.

Paradox as a diagnostic tool

We have already mentioned some paradoxes that afflict the governance of risks. In our dominant philosophical tradition, the standard reaction to paradoxes (which are expressions of contradictions) is to try to 'solve' them. In the classic case of Zeno's four paradoxes concerning motion, two and a half millennia of effort has gone into showing that they are not as damaging as they seem; yet, as the philosophers say, Achilles is still running. In the most famous of the paradoxes, Achilles, the quickest runner, raced the tortoise, who was given a head start. Soon Achilles halved the distance between them, then he halved it again, and again, and again.... How can we describe the act of his catching up? Is there a last jump, where one-half of the previous finite gap is zero? No! Hence the paradox: although we know that Achilles really does catch up with the tortoise, in this scheme of describing the process we cannot describe how it happens.

Another approach to paradoxes, characteristic of other cultural traditions, is to accept them and attempt to learn from them about the limitations of one's existing intellectual structures. Most notably, this is the way of Zen. It happens here too, outside academic circles. One great novel of the 20th century taught its lesson through a paradox: 'Catch-22'¹⁴. This was applied to American airmen who had been on what they thought were enough dangerous missions over Italy. Just saying that they wanted to get out was not sufficient; so some tried to say that their mental health had suffered. But then the Catch-22 operated: if they knew that the job was making them mentally sick, that was proof that they were mentally healthy! There was no simple way out; and indeed, had there been one, the war could not have been fought. It required a work of fiction to convey the paradoxical nature of the whole situation, where the Catch-22 summed up the intimate mixture of sanity and craziness, heroism and corruption, that are there in society all the time but are exposed so clearly only in the conditions of a war.

So let us try the thought-experiment of seeing our present problems of safety as a structured set of paradoxes. Also, before we rush in to remove the paradoxes, let us see what we can learn from them. We might call it the 'Triple Catch-23', since it involves three elements, the economy, government and the public, all in a dance around different sorts of safety and danger.

In the global knowledge economy,
constantly accelerating innovation
buys temporary safety for firms against their competition
but cannot guarantee the safety of their innovations in the environment.

In the face of these possible dangers from innovations,
governments
lose public trust by reassurances of their safety

and regain public trust by admission of their danger.

But by admitting danger and thereby inhibiting innovation,
governments
lose safety in the politics of the global knowledge economy.

Such a closed-cycle paradox is perhaps more reminiscent of Lewis Carroll than any other literary source; it plays a more elaborate joke on the reader than the classic Zen riddles like 'the sound of one hand clapping'. Its sources in my own thinking are varied; they include Dovers and Handmer's discussion of contradictions in the idea of 'sustainability'¹⁵ and Les Levidow's discussion of tensions in the British system for regulating biotechnology². And, however strange its appearance, it does have the merit of expressing the essentially paradoxical structure of the general problem, as well as exhibiting the various senses in which 'safe' is deployed. It is not to be understood as a set of rigid entailments; rather it exhibits the contradictions that affect the total system of the global knowledge economy. Let us go through it, elucidating the points made in the successive theses.

The first relates to an inherent structural feature of the global knowledge economy; here 'safe' refers to the wellbeing or even survival of a firm. Stock market evaluations of innovative firms can lose billions of dollars in a day, and then gain them back in a week. For the real security of the modern firm, capital value and present sales are nearly irrelevant; what counts is what is in the R&D pipeline. Without a prospective innovation likely to become a monopoly in its field, a firm can lose the confidence of its speculative investors, lose value on the stock exchange, then encounter cash-flow difficulties, and soon be little more than a division of some more successful predator.

In the next thesis, the 'safety of innovations' refers not to them (or their firms) but to their effects, in their human, natural and social environments. As we know from the example of pharmaceuticals, the guarantee of safety of a biological agent, even in that limited context of medical use, can be achieved only at very great cost of time and resources. Given the complexities of possible patterns of gene-flow and expression, our ignorance on safety of environmental releases (deliberate or accidental) is, as it were, multi-dimensional. Any hope of 'facts' which could prospectively guarantee the full safety of these novel entities must be forlorn indeed. This is not to say that there is a total absence of facts, nor that policy debate is impossible; only that the official 'normal' scientific expertise is simply unable to guarantee safety on its own. We are now in the age of policy-critical ignorance, and to deny it is to become a victim to its paradoxes.

When governments make reassuring pronouncements, the logical response, particularly in the UK after BSE, is, 'Why should we begin to trust you now?' For years, the established authorities put their reputations on the line, assuring the public that British beef is safe, and that by implication the critics were mischievous and ill-informed. There

is the classic photo of a Minister of Agriculture feeding a hamburger to his unwilling six-year-old daughter; and there are the many video clips of officials of the highest rank solemnly reassuring the public of the safety of British beef for humans, long after it was known to be dangerous to cats.

For people to 'feel safe' it is not necessary to be convinced that a particular risk is at zero or negligible level. As we have seen, 'safety' is not a subjective equivalent of 'risk-free'. Rather, relating to the pragmatic and moral context of a hazard situation, it is about trust in those charged with protecting oneself and one's family. Hence we can state the most paradoxical of the theses: that by admitting an innovation to be dangerous, and thereby taking the public into its confidence, a government can actually make them feel safe in its hands, as it copes with this and other dangers. Although this proposition might seem the most counter-intuitive of all the paradoxes, it has empirical support, in the striking reversal of attitude on GM foods by the British Prime Minister, Tony Blair. In contrast to his original confidence, at one point he suddenly changed his mind and agreed that the critics had a case¹⁶.

But any such government taking the side of its citizens on safety could itself fall into a bind: in the global knowledge economy, the burden of proof is effectively on those who would stand in the way of progress and free trade. If the three-man committee at the WTO decides that the evidence of risk is insufficiently strong, then further resistance is fruitless; or alternatively continued obstruction could introduce new and potentially very damaging elements into the diplomatic game. In this way, the safety of the nation could be compromised by an insistence on guarantees of the safety of particular innovations. But public outrage at the betrayal of its personal safety by the WTO and the government might then introduce new sources of conflict and instability. This could give rise to new attempts at enforcing conformity, and in the inevitable reaction, further threats to the safety of the state and society.

Thus the cycle of paradoxes is complete. It describes a situation that starts with the pressures on firms in the global knowledge economy, develops through 'safety' as ordinarily understood, and concludes with the paradoxical requirements on nations in the global knowledge economy, as expressed through its own transnational governing institutions. This is the context in which the 'trust' of citizens in their governments is threatened. One may say that in this new globalised struggle for existence of firms, trust in governments is the first casualty. The further consequences of such a confrontation, political or constitutional, are beyond the scope of this discussion. We have already shown how one essential element of trust in the modern state, official scientific expertise, is already showing the strain.

Paradox as a way of thinking.

Since our culture is so antithetical to paradox, it might seem that the cycle just displayed above is something frivolous or lacking in serious significance. What can one do with such paradoxes? No practical policy can be established on such a counterintuitive foundation. In response, I would argue that, especially in recent years, our society has depended on paradoxes in some crucial areas, but hitherto has simply not given them sufficient recognition.

For the first example, let us consider 'nuclear deterrence', which has been in force ever since there were weapons of mass destruction (H-bombs) and effective delivery systems (intercontinental ballistic missiles). For some decades, the ruling doctrine had been the paradoxical (but intentioned) official acronym MAD (standing for Mutually Assured Destruction). Under this regime, responsible persons on either side must be ready to commit one of the greatest war crimes ever, the genocide of present and future generations, and possibly unleashing a global 'nuclear winter', under either of two circumstances. The first is 'genocide on suspicion', if there is sufficient reason to believe that the other side is starting an attack. The other is 'genocide on revenge', in case the other side succeeds in launching its 'first strike'.

It has been argued that such a readiness can be quite moral, provided that it ensures that the act will never occur. The argument may indeed be valid, but the air of paradox cannot be dispelled. Yet such paradoxes are at the foundation of the continued possession of nuclear weapons by the original members of the nuclear club; and their continued efforts to persuade other nations to forswear nuclear weapons become quite paradoxical indeed. Further paradoxes in the argument for possession of 'independent' nuclear weapons by the original second-rate powers need no elaboration here. There is no suggestion that those advancing such paradoxical arguments are acting in bad faith. They are doing their best in a situation where paradox is built in, because of the combination of a new destructive technology with old political structures. Up to now nuclear deterrence has seemed to be unique in its paradoxical structure; but, as we have seen, the problems of safety of new civilian technologies present analogous structural features.

In the management of risks, even ordinary ones, some paradoxes are easily discerned. In the logic of analysing hazards, it is well known that it is impossible to prove an impossibility. Hence 'zero-risk' can never be guaranteed, and so the policy on risk management will depend on assigned levels of what is 'tolerable' or even 'acceptable'. These technical terms have an explicit ethical aspect, and so it becomes clear that while risk 'assessment' may be a purely scientific exercise, risk 'management' is inescapably political. Another paradoxical feature of the practical management of risks is that 'success' is assessed in terms of something not happening, namely the unwanted events which the policy is designed to prevent. This may not be strictly paradoxical, but it is certainly counter-intuitive in our culture, where rewards are normally given for actions

rather than for inactions. It might even be considered a sort of Zen situation, that no-action is the sort of action that we want to have.

The concept of 'safety' seems to be uniquely effective in exposing some of the deeper contradictions in our whole system of knowledge, which hitherto remained largely latent. Thus the question 'how safe is safe enough?' comes up whenever there is a contested standard for 'acceptable risk'. First, the form itself is paradoxical; is there is a degree of safety that is not safe enough? Also, since safety (unlike risk) cannot be reduced to a single-dimensioned measure, there is an ironic paradox in the question itself. And finally, it is quite clear from the question that safety is, to some extent, in the mind of the beholder. What is safe enough for the agent who imposes or regulates the risk, may well not be safe enough for the person who endures or who rejects the risk. So the simple question of 'safe enough' reveals that safety is a matter for negotiation, in which there are no simple measurements that can resolve the issue by an appeal to Science. It may even lead on to the recognition that the issue in safety is not so much in absolute quantities of probabilities and harms, but rather in the competence and trustworthiness of those who manage the risk on behalf of others. Thus the paradox of 'safe enough' is quite instructive, in leading us from the reductionist concept of 'risk' to the full systemic concept of 'safety'.

With an appreciation of the systemic character of safety, we are prepared to comprehend the force of the old Latin motto, 'Who guards the guardians?'. This reminds us that safety, like other sorts of quality, is a recursive attribute. It cannot be captured at a single level, since all guardians need to be guarded. And it immediately opens up the prospect of an unbounded regress: if we need [guardians]², then why not [guardians]³ and so on? In practice, the recursion stops at some informal level, when the public is engaged through its 'opinion' or 'consensus'. This is, admittedly, a highly imperfect mechanism; but it is important to realise that it is essential to the processes of governance, on safety or any other regulatory function. Otherwise, the processes of control stay in a closed loop, and, as experience shows, are totally vulnerable to corruption there.

Finally, debates on safety, unlike analyses of risks, bring out ignorance as a key element in any inquiry. With the plurality of perspectives, it is difficult for anyone to frame an analysis which ignores ignorance. The participants must confront our ignorance of the ramified or long-term effects of our multitudinous interventions in nature, which may be severe and irremediable. In many cases, if indeed not most or all, a prudent concern for safety would lead to a 'precautionary' moratorium on a broad front of innovations. Innovation and growth as we have known it would be inhibited, or would flourish in locales where regulation is lax or nonexistent. But ignorance will not go away, since we have seen too many examples of the malign effects of its belated discovery. It is now becoming quite fashionable to cite aphorisms about ignorance, such as 'It's what you don't know that you don't know, that you need to worry about'. Here the paradoxes

positively shriek. How can you possibly worry about things that are so weird? Yet these are precisely the focal points of concern.

Once we are aware of the presence of paradoxes in so much of our thinking, we can begin to use them creatively. The 'Safety Catch-23' might be seen as a symbol of the great paradox of our industrial civilisation: that in the pursuit of safety, comfort and convenience for ever-increasing numbers of people, it is causing and further aggravating instabilities in the global climate system which might damage our civilisation as deeply as a nuclear war. Reflection on such a fundamental paradox might induce us to devise what Sheila Jasanoff has called a 'technology of humility', where we begin to come to terms with our ignorance¹⁷. This will be a major task of philosophical construction, since the history of modern European thought, starting with the generation of Descartes, was based on the suppression of the tradition of awareness of ignorance that had extended back to Socrates. So much of our modern science has been based on the ignorance-of-ignorance, that a wholesale reform of philosophy, pedagogy and practice will be required. The work is already underway, with earlier reflections by myself¹⁸ and recent comments by colleagues including Brian Wynne¹⁹.

Implications for policy

We have shown how such closed-cycle paradoxes can be used as a diagnostic tool for social systems. If the entailments are too tight, and the paradoxes are truly insoluble, then that is a sign that there is no flexibility in the system. It is known for social systems to collapse (the Soviet Union), to be replaced by revolution (France in 1789), or to have their conflicts resolved by civil war (the United States in 1860). Hence a positive use of closed-cycle paradoxes is as analytical tools, displaying the destructive contradictions in a social system in such a form that their possible openings or softenings might be explored. Social systems can evolve so that structural conflicts are resolved somehow, and the characteristic contradictions take on a new, less destructive form. In one sense, our present predicament results from a resolution of the nineteenth-century social problem of distribution, not by an expropriation of property as then advocated by Socialists, but by an enlargement of production partly through an intensified expropriation of nature. Safety from the traditional crude dangers of poverty and pestilence has been achieved, but at a price of which we are only now becoming aware.

Let us see whether, and how, this particular cycle of paradoxes can be modified so as to shed its closed, destructive form. For the first phase, we admit that at present, there is no substitute for constant innovation; but if some technologies fail to fulfil their much-advertised promise (as so many do), there could be opportunities for pauses for reflection. Again, for a public dialogue on dangers of innovations we do not need a 'guarantee' of perfect safety; the public is now more sophisticated than that. Counterproductive reassurances by governments occur when trust has been lost; should trust somehow be regained, then this third paradox loses its force. And some

governments have already opted for 'safety' on some issues; on the issue of GM seeds and crops, various Member States have adopted delaying tactics, hoping to find safety in the labyrinthine procedures of the European Union²⁰. Finally, even if the WTO disagrees with a government's assessment of safety, that could be but the start of a lengthy process, in which (as we know by previous examples) coercive power is not all on one side. So in practice, the operation of the paradoxes could be muddled and modified as they work out, in a variety of ways. Thus they could indeed function for us as an analytical instrument rather than as a simple prediction of doom and disaster.

Since the safety paradoxes relate so centrally to ignorance, a renewed awareness of this category can also have positive consequences. The inherited faith in the infallibility of scientific facts, inculcated by generations of schoolteachers and popularisers, is now eroding rapidly. With it goes the mystique of 'experts', who are now appreciated as quite necessary but far from sufficient for the resolution of science-related policy issues. Over the years Brian Wynne has shown how risks issues have been misconceived through a reductionist framing of the scientific problems²¹; and his lesson has now been learned. There is a now developing something of a bifurcation within science. On the one hand are those in the classic laboratory-based reductionist disciplines, which still enjoy great success in their own terms. Their methods are designed to avoid the pitfalls of accepting nonexistent correlations as real, and so they emphasize specificity rather than sensitivity (usually measured in a demanding 'confidence limit' on statistical tests). But in relation to problems of safety this approach encounters the pitfall of rejecting possible real and significant correlations as nonexistent. Data that is ambiguous or weak is rejected as 'unscientific' and never appears in the literature even as a warning. Thus 'sound science' is not as objective as it seems, but has a built in bias in favour of innovation rather than safety.

By contrast, it is the newer policy-relevant sciences which are called in to solve the systemic environmental problems that the traditional sciences have created through their successful applications. In these latter post-normal sciences, value-loading, context, uncertainty and policy-critical ignorance are all elements of the research problem²². In their framing, we will look for the new 'what-if' and 'what-about' questions as well as the traditional 'what-how' and 'how-why' questions²³. The solutions to such problems are best seen in terms other than as simple approximations to truth, rather as something more pragmatic, be it the 'serviceable truth' of Sheila Jasanoff²⁴ or the 'socially robust knowledge' of Nowotny *et al*²⁵.

The distinction between the two styles has its political aspects. The traditional reductionist scientific approach seems perfectly adapted for the needs of the leading-edge firms of the global knowledge-based economy. This is constrained to ignore the systemic, contextual aspects of its work including uncertainty and policy-critical ignorance²⁶. Should there emerge a polarisation between interest-groupings, with leading multinational corporations and their home governments on one side, and

opposing citizens' groups and overseas governments on the other, then these methodological contrasts might well become highly politicised. Since the European Union now states that 'decisions must be supported by transparent, responsible opinions based on ethical research'²⁷ there might well arise a systematic divergence between the EU and other governmental institutions.

The use of paradoxes has its own policy relevance; for it helps us to escape from the illusion that such inherently self-contradictory policy problems can be solved on the analogy of textbook exercises in science. That vital lesson was learned by the first generation of experts in nuclear strategy after a few years of attempts to simulate the paradoxes of megadeath-threats by either mathematical models or interactive 'games'²⁸. And even when we show how the paradoxes can be softened, they are still there as reminders of the vulnerability of our political, social and natural systems. The paradoxes, rather like a Zen riddle, perform the Socratic function of helping us know ourselves and our limitations. In that way they make the necessary politics of policy-critical ignorance more plausible, and hence more effective, in spite of its strangeness after four centuries of scientific triumphalism.

Conclusion: paradox and post-normal policy

The world of policy comprehended as paradoxes is the conceptual and societal context in which the new politics of 'participation' has a genuine meaning, as opposed to exercises in public relations. This is the 'post-normal' world of science policy, in which scientific demonstrations are complemented by stakeholder dialogues. In these, all sides come to the table with full awareness that their special commitments and perspectives are only a part of the story, and with a readiness to learn from each other and to negotiate in good faith. Such a process may indeed seem paradoxical to those raised on the verities of traditional natural science, in which every problem has one and only one correct answer. It would be equally paradoxical to those whose politics assumes that their own side has the unique possession of reason and morality. But it is only through grasping all such paradoxes that we can resolve the riddles of safety in the global knowledge economy, develop a politics of policy-critical ignorance, and move forward to a new creativity in science and governance alike.

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