The Tragedy of the Rationals

Abstract

Within the context of policy making, we discuss to what extent complex, uncertain scientific information can be collapsed into crisp, exact guidelines and what is gained by doing so. We view policy making as a de-fuzzifying filter which needs to convert ambiguous and potentially contradictory information into unambiguous regulations. Similarly, a de-fuzzifying filter is needed to convert uncertain scientific information into exact guidelines. We question whether this second filter is necessary and suggest that in complex problems information about scientific uncertainty should contribute, unfiltered, to the decision making process along side other uncertain factors.

At the heart of the current expectation for science to simplify decision making by providing definite answers to ill-posed problems lie three assumptions: first, that more precise information leads to more rational decision making, second that rational decision making naturally leads to rational outcomes and third that science is the realm of rational thinking. We challenge all three assumptions and argue that the acknowledgement of scientific uncertainty not only would enhance policy making but also would recognise the true nature of scientific knowledge and its meaning within the context of human affairs.

1 Introduction

We are witnessing an increasing disillusion about the ability of political and economic rationalism to deliver well-being and effective governance. This disillusion is mostly based on a perceived widening gap between the original aims of political and economic decision making and the actual criteria on which such decision making is carried out.

The search for political and economic rationalism is based on three assumptions: 1) that rational premises necessarily lead to rational outcomes; 2) that rational decision making is less prone to subjective bias and manipulation and 3) that precise quantification of uncertain processes leads to improved understanding and better informed decision making.

Science has a role in all the points above. Pragmatically, it can help policy making by addressing points 2 and 3: it can provide the precise quantification of uncertain variables needed for decision making and by doing so, ensure an unbiased approach. Conceptually, science can be an inspiration and a motivation for point 1: as the perceived utmost achievement in mankind's search for rationality, it can represent a theoretical justification for the 'rational premises → rational outcomes' relation.

In this paper we want to challenge all three premises. First, science provides evidence of many cases in which rational decision making leads to irrational outcomes. Second, there are cases in which scientific knowledge consists of detecting, explaining and quantifying uncertainty rather than certainty. In these cases, the requirement for crisp and precises answers to fuzzy policy questions goes against the very purpose of science: the description and understanding of Natural processes. If demanded, this requirement may result in worse, not improved, decision making and in opportunities for manipulation. Finally, the very view of science as the utmost rational human activity, which is partly responsible for current public mistrust, needs reviewing since it does not encompass the main features which distinguish science from other human activities.

To be useful, the challenge to the three premises needs to lead to a better way to employ science in policy making. We suggest two ingredients: first, that uncertainty be accepted and understood as positive information about the problem to address rather than as an obstruction to problem simplification. Second, that the *meaning* of scientific knowledge be understood as something broader and richer that the provision of hard numbers with which to associate thresholds and limits. A failure to recognise this can lead to what we call the 'tragedy of the rationals'[1] paraphrasing the well-known 'tragedy of the commons' which, we will show, can be seen as a special case.

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[1] In the rest of the document the words 'reason' and 'rational' refer to decision making based on the application of a system of pre-defined rules and assumptions. This is not a formal system as intended in logic and mathematics, since it is open to modifications, that is its rules can be changed by policy-makers. However we assume that changes to the rules, when they happen, will only follow fixed a-priori assumptions and beliefs and not radically change the context of the policy approach; for example a believer in economic rationalism may propose different alternative rules, all of which are in accordance with the a-priori belief in the success of free-market economy.

2 Science and exact knowledge

In the eyes of many a physical law represents the utmost achievement in the human understanding of Nature. It highlights the ability of humans to detect, discriminate, extract and represent the effect of one among many interacting physical processes.

Scientists and philosophers know that simple and elegant physical laws are hard to find; more often scientific knowledge is expressed by fuzzy rules, heuristic relations and records of observations which will unlikely ever be condensed in simple closed-form equations. If definite prediction results from a physical law, knowledge which is both conditional and probabilistic arises from these more ambiguous forms of scientific knowledge.

Scientists have learnt to accept this and so has the public: everyday people watch the weather forecast and take a decision on whether to carry an umbrella or not, knowing that the forecast may not be exact. More recently the public is increasingly expressing its political preference for a cautionary approach to the risks of global warming despite its effects are not certain and are not expressed by a simple and elegant physical law.

Less comfortable with this state of scientific affairs seem to be the entities that lay between the scientists and the public and that increasingly regulate their interaction: decision making bodies, to which a crisp piece of scientific information is often preferable to a fuzzy one even when the conditions for scientific precision are not met. In extreme cases the 'scientific → precision' assumption is reversed leading to an even less likely 'precision → scientific' relation, with great risk for unwarranted decision making as well as openly misleading the public (Ackerman and Heinzerling, 2004).

The risks associated with the requirement for scientific precision and the purposeful misinterpretation and manipulation which can arise from it are widely known. In the following we discuss some related issues: how a fuzzy piece of information is converted into a crisp one, the assumptions that crispier scientific knowledge necessarily leads to better decision making and the role of scientists in such decision making process.

3 Decision making as de-fuzzification process and logic: meaning vs rules.

Policy making by definition requires a crisp outcome. For the purpose of our discussion it may be useful to think of policy making as a de-fuzzifying filter which takes fuzzy information as input and needs to produce crisp, clear regulation as output. This analogy has a strong computer science connotation but it is not difficult to see it in action within a policy making context.

First, we may consider the number of components contributing to policy making: economic, political, social, ethical factors all provide information which is inherently fuzzy and potentially contradictory; the outcome of policy making has to be a regulation which is as clear and unambiguous (thus as crisp) as possible. Secondly, we may consider the purpose of a policy; this may be stated in very broad terms: for example reduce carbon emissions, or improve the health system; the specifics of the regulation however need to crisply spell out what it is to be done.

The latter example can be seen as an attempt to implement *meaning* (purpose of a policy) via *fixed rules* (regulations), a problem which has been studied extensively in the field of artificial intelligence, cybernetics, mathematical logic and philosophy. There is a relation among the meaning of 'law' in scientific knowledge, 'rule' in social behaviour and 'instruction' in computer science in the sense that they share three important features: a) they all imply inevitability (Rosen, 2001), b) they all apply only when precise conditions are met and c) they can not include specifications for their own modification (Boschetti et al., 2008). These three features provide a way to codify desired human behaviour and regulate human interaction: if we wish to prevent people from stealing and we want this to apply fairly, uniformly and consistently within a large population, we need to specify what stealing means, under what conditions stealing will be persecuted and what penalties an offender will face. Here the *meaning* of the regulation is to prevent people to unfairly take possessions of properties belonging to others, while the *rules* are the instrument needed to apply the principle fairly and equitably.

The symbiosis between the meaning and the rules provides a particular effective tool for managing human affairs, which neither in isolation could achieve: meaning without the rules is subjective and open be applied in non equitable manner; rules devoid of meaning would clearly be unacceptable. The final aim thus is for the rules to *actuate* the meaning. The crucial question for our discussion is whether rules could *replace* the meaning; that is, once the proper rules are found, can we trust that an effective translation 'meaning↔rules' has been achieved? Was this possible, we could in principle dispense with the fuzziness inherent in the arguments behind the definition of the meaning and proceed in the crisp world of the logic defined by the rules.

Would it work? The answer is a confident no. Not only experience says so, as centuries of legal litigation clearly show, but so does logic and science as we discuss in the next section. A set of perfect rules which allows us to replace, and thus dispense of, the meaning of policy making can not be found. This does not suggest that we should give up the search for a suitable set of rules or regulations, rather that the rules, once defined, still need to carry the meaning attached to it, an unreplaceable pointer to the reason why the rule was set, something to return to in the inevitable situations in which the rules alone will not suffice to determine what action need to be taken.

4 When do rational premises lead to irrational outcomes? A logic and scientific analysis

The scientific literature is full of examples in which rational premises lead to irrational outcomes or at least to outcomes which can not be proved to be rational. Here we briefly review a few cases.

The limits of logic. The fundamental limits of rational rule-based analysis (Godel, 1931; Turing, 1936; Chaitin, 1997) are today widely known. Nevertheless, they seem to affect both scientists and the layman less than other statements of the limitation of human knowledge, like the uncertainty principle and chaos theory. The reason lies mostly on the belief that, unlike the latter, the first apply solely to the arcane word of logics, not to everyday life. While it is true that the famous theorems proving the limits of logics apply only to formal systems and that human affairs can not be framed within such strict constraints, it is nevertheless useful to be reminded that even if we could develop a perfectly rational governance system, this would not screen us from the occasional dilemma of uncertainty or contradiction (Hofstadter, 1985).

Rules leading to unexpected consequences. It is difficult to predict all possible outcomes arising from the interaction among even very simple rules; this is why no computer program comes without disclaimer of potential bugs, mathematicians frequently discover new rules in arithmetics and routinely new ways are found to circumvent the law without breaking it. This phenomenon is responsible of the sense of surprise computer scientists are so familiar with when using programs as simple as the game of life (Gardner, 1970) or study the properties of chemicals of known molecular structure. The message is clear: rule-based rational decision making can lead to unexpected outcomes in the hands of rationally-bounded (= human) agents.

Generation of novel processes. Formal systems are 'closed': their behaviour is determined solely by the given rules and the rules define all that can happen in the system. But natural systems are 'open': they interact with the outside world and may encounter processes and events we did not account for. The outcome is deeper form of surprise, at times also classified as emergence (Prokopenko et al., 2008). The message, once again, is simple: rules will always need to adapt to novel circumstances and the criteria needed to address such novelty can not be contained in the rules themselves. Novel decision making criteria are needed to address genuinely novel circumstances.

Local minima, game theory and competition. We all know that at times a sacrifice is needed for later gains; in the numerical optimisation parlance this is the difference between local and global optimal performances: in order to reach an optimal configuration, steps which temporarily worsen our state may occasionally be needed.

Probably the most striking examples on this problem arise from the game theory literature and have been popularised under the names of 'tragedy of the commons' and 'prisoners' dilemma', in which behaviours which are advantageous for each individual agent lead to overall community failure and thus, as a result, failure for the individuals themselves. Some authors claim that these paradoxes highlight the limitation of reason in the management of human affairs (Campbell and Sowden, 1985). Since it is often assumed that following an advantageous behaviour is 'rational', this example shows how the 'tragedy of the commons' and its analogues can be seen as a special case of what we figuratively call the 'tragedy of the rationals'.

Forgetting the assumptions or using rules for purposes different from the ones devised for. Currently a considerable amount of scientific input to policy making comes via numerical modelling. Numerical modelling, whether via computer simulation or via equation solving, implies executing algorithms which are rule-based processes. Even disregarding purposeful manipulation of results, numerical modelling is thus a potential source of misleading outcomes exactly because of its automated nature. As we discuss extensively elsewhere (Boschetti et al., 2008), the outcome of a modelling exercise depends crucially on the assumptions inherent in the input and details of the algorithm. Some of these assumptions are clearly stated, others less so and occasionally may be forgotten; this may lead to extending conclusions deduced from a model to situations in which the assumptions to do apply. This is especially dangerous when a model designed for a purpose is generalised and used for different problems and run by different users. The typical example in policy making is the assumption of perfect rationality and complete information used in classic economic models.

Other examples include the use of cellular automata in modelling processes as disparate as fire-fighting, spreading of epidemics and crowd behaviour. Clearly such approaches will model human behaviour only when a human behaves as an automaton; extending the conclusions so obtained to situations in which humans make use of higher intellectual activities or ethical decision making would naturally be flawed.

5 Does crispier scientific knowledge necessarily lead to better decision making?

We have seen that decision making can be seen as a 'de-fuzzifying' filter which needs to collapse a potentially vague requirement into a definite statement. A similar role is fulfilled by *quantification* in science when the problem is complex, is formulated into probabilistic form and sufficient information is not available. For example, providing a scientifically justified exact ceiling to carbon emission in order to address global warming is an attempt to collapse a large body of fuzzy and uncertain scientific knowledge into a single number, representing a crisp threshold. This may be necessary and even useful, provided the knowledge (and possibly quantification) of the uncertainty is attached to such threshold. Should information on the uncertainty be lost, and the crisp threshold be reduced to a hard number, there would be a significant risk that the *meaning* of the scientific information also be lost. Needless to say, a crisp threshold including a pointer to uncertainty is no longer crisp. What is the way out of the dilemma? In other words, we ask whether scientific information needs to be crisp to be useful in handling complex problems and if so, at what stage in the decision making process should scientific de-fuzzifying occur?

The question is represented graphically in Figure 1, which describes a simplified flow-chart of a policy making process. The grey ovals with broken border represent fuzzy knowledge, which for complex problems includes science. Grey rectangles represent the de-fuzzifying filters: the final decision making which defines the regulation and the scientific act of collapsing complex information into a hard number or a threshold. White rectangles represent crisp information. The top part of the figure, flowchart A, shows how science is often asked to contribute to policy making by providing a crisp piece of information which is then analysed together with the fuzzy information provided by other fields of knowledge. The bottom part of the figure, flowchart B, shows an alternative flowchart in which scientific information is not de-fuzzified priori to decision making and, carrying its own inherent uncertainty, contributes to the decision making as a fuzzy entity on the same ground as other factors. The previous questions can then be framed as follows: first, how can we decide when flowchart A can be used in place of flowchart B, thereby making the decision process easier? Second, should there be no ground to justify the choice, would anything be gained by using flowchart A rather than flowchart B in term of decision making quality? While flowchart A may make the decision making simpler, would it make it more reliable?

Our answer to the first question is fairly simple, though surely controversial: de-fuzzification of uncertain information should not be accepted if the criterion employed to do so would not be acceptable by a peer-reviewed scientific journal; in other words, *if a criterion is not good enough for a scientific journal, even less it should be so for decision making involving real people*. It is often argued that the criteria for scientific acceptance are useful in the theoretical setting of the slow pace academic discourse and may fail when a practical advice is needed urgently: the immediacy of real life decision making may not afford to wait for academic agreement. We agree fully and we are not suggesting that current scientific advice, whatever its status, should not be made available; we simply suggest that lack of an agreed upon avenue for de-fuzzification may represent the status of our best scientific knowledge and the scientific advice in those cases should be given together with the inherent uncertainty it includes. The answer to the second question follows naturally: in such situations flowchart B should be chosen to flowchart A; scientific de-fuzzification needs to happen at the stage of decision making since nothing is gained and avenues for manipulations would be opened by from doing so prior to it.

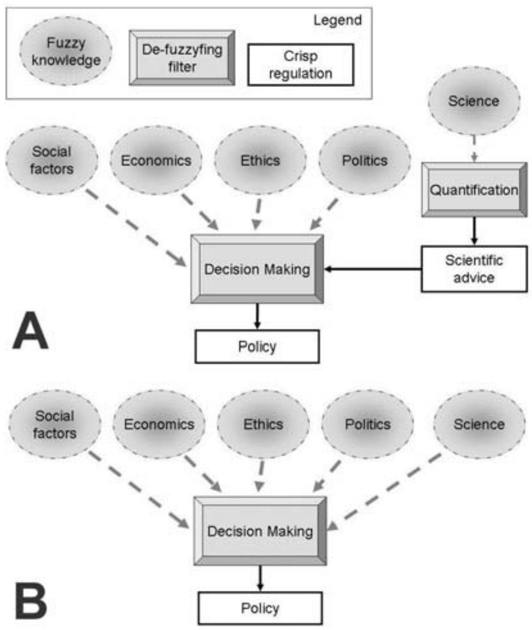

Figure 1. (A) Scientific advice contributes to decision making by first collapsing potentially fuzzy scientific information into crisp numerical information via quantification, which is then accounted for in the decision making process, along with other fuzzy contributing factors. (B) Scientific advice contributes to decision making at the same level as other fuzzy contributing factors. Our question is when A should be preferred to B and what it is gained by doing so.

Implied in our discussion is the existence of 'meaning' contained in scientific knowledge which goes beyond the provision of crisp information represented by hard numbers: for example, most scientists would say that the 'meaning' of current studies is that global warming is worth addressing seriously, independently on the exact numerical output from climatological models which represent the probabilities of specific events to occur. Scientific 'meaning' can contribute to the de-fuzzification implied in decision making along side other social and economic considerations which share an inherent fuzzy nature.

While the previous example is reasonably clear-cut, others are less so. Will genetically modified crops help or endanger mankind? Do powerlines and cell-phone signals harm human heath? Is unlimited economic growth sustainable in a world of finite resources? When asked to provide a definite answer a scientist may be faced with an ethical dilemma: should he/she provide an uncertain answer dressed-up with certainty at the risk of such answer being unwarrantedly used for decision making possibly impacting the life of millions? Or should he/she refuse to provide an unreliable answer at the risk of the decision making taking place anyway with no scientific input at all? The provision of the 'meaning' of a piece of the scientific knowledge may show a way out of the dilemma.

6 Does ‘science = reason’?

We argued that when a problem is sufficiently complex, the contribution science can provide is not qualitatively different from the one offered by economics, politics, social science and ethics: they all are fuzzy, subjective and uncertain. So what about the commonly held view of science as the ultimate rational human activity? This view places science at the opposite end of artistic creativity, superstition and religion. Curiously, while this view has at different times in history given hopes for a science of policy making, is also partly responsible for current hostility towards science in certain sections of society.

That view is incomplete, to say the least. Logic, not science, is the ultimate rational human activity; science *employs* logic, it is *not* logic. The ultimate essence of science, what most uniquely sets it apart from other human activities, is observation and experimentation. While it is true that scientific arguments need to be consistent (and thus they employ logic), observation in science has a more fundamental role than reason: if an observation contradicts the prediction of a theory, it is the theory which is deemed wrong not the observation; creativity and imagination then are needed to devise a new theory. The *purpose and meaning* of science, the understanding of Nature via observation, prevails against the *rational* role of the theory. As nicely described in (Feynman, 1999) the prevailing feature of a scientists is scepticism, the will to disregard a dogma, even a scientific one, if observation demands it.

Ironically, if we identify reason with rule-based systems (as is currently accepted), then many human activities should be seen as more rational than science: we refer to all belief systems (including some religions) which, unlike science, are characterised by unchangeable dogmas, defended not only in the light of contradictory observations but also against internal inconsistencies. Maybe the widely accepted Enlightenment’s vision of science as a rational barrier against superstition should be reversed and science should be seen as offering the ‘plastic’ meaning of observation against the rigours and dangers of dogmatic reasoning, be this represented by religion, economic rationalism or cost-benefit policy making; science is as creative and plastic as art, it is the art of making sense of Nature and this would be a more useful way to present it to the public.

7 Conclusions – the role of a scientist

Most policy making problems are complex and complexity often leads to frustration: the instinctive reaction is to look for simplification; a crisp scientific statement is often seen as a step towards such simplification.

In fact, most complex problems can not be simplified without losing sight of the essence of the problem. As nicely described by (Dorner, 1996) and (Feynman, 1999) such short-sightedness will bite back since “*Nature can’t be fooled*”. Science itself suggests that crisp, exact statements can not replace meaning, do not necessarily lead to more ‘rational’ or ‘exact’ conclusions and do not necessarily simplify a complex problem.

The recent past has shown that hard data can be as ‘fuzzy’ and as prone to manipulation as meaning is commonly thought to be. What is at stake by getting these processes wrong is obviously the wellbeing of the public which should be the real end recipient of scientific work. Also at stake is the trust of the public in science. Releasing scientists from the requirement of expressing scientific statement via ‘hard data’ and enabling them to communicate the scientific ‘meaning’ of their knowledge is not a call for looser or weaker science, nor for providing scientists with more influence than is warranted. Rather it is a call for informing decision makers and ultimately the public on the real extent and value of current scientific knowledge, protecting its value against the manipulative interpretation hard numbers often undergo and ultimately allowing scientists to fulfil a social commitment that most of them share; despite the all-too-frequent exposure of conflict of interest, the vast majority of scientists would gladly act as brokers for public concerns in issues like health and environmental protection, social fairness, precautionary principles, to name few.

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