Policy via Science

E3 Foundation
Discussion Paper 2011-01

Martin Sewell
mvs25@cam.ac.uk

1 January 2011

Abstract

This note outlines a general framework for conducting policy-relevant science. I argue that science is essentially applied subjective Bayesian inference, and that putting a probability on a hypothesis is necessary, but sometimes difficult. An effective policy should accommodate our innate degree of altruism. For example, individuals are motivated to invest something like 3% of their resources into humanity as a whole, which has implications for international policy. In order to accommodate policy decisions that affect our future, one must determine the social discount rate. I argue that an individual's discount rate is hyperbolic and reaches 100% at the end of their lifetime, and take the social discount rate to be the average of the population's individual discount functions. Policy is determined with recourse to the normative model of decision making under risk, expected utility theory. It is shown that, in science, a more surprising hypothesis requires more evidence, but in terms of policy, a lower expected utility requires more evidence. The latter is consistent with the precautionary principle. Policy should be made with recourse to the science, all of the science and nothing but the science.

What is science? Hume (1740) pointed out that 'even after the observation of the frequent or constant conjunction of objects, we have no reason to draw any inference concerning any object beyond those of which we have had experience'. In other words, one can never generalize beyond one's data without making subjective assumptions, so science always involves a degree of uncertainty. If we insist upon intimating one's degree of uncertainty and self-consistent reasoning, science becomes applied subjective Bayesian inference (observing some common sense criteria, science should also be constrained by exchangeability (de Finetti 1937), the Reflection Principle (van Fraassen 1984, 1995) and the Principal Principle (Lewis 1980)). Thus, science involves putting probabilities on hypotheses. In practice this can be problematic; for example, Taleb (2010) argues that the probability of unexpected events cannot be calculated. Ayache (2010) contends that probability has things backwards, and replaces probability with a market-generated price. However, relying on betting on anything but the relatively near future is difficult, because the future (including any pay-off) is discounted and the punter may not even be around to collect any winnings. I offer no solution to the difficulty of assigning prior probabilities, but a recommendation to those of us conducting science: must try harder. Although distilling a hypothesis to a probability should help reinforce the fact that a scientist should be free of any ideology: using a scientist's abstraction, a hypothesis is not simple, complex, popular, fashionable, left wing, right wing, racist, sexist, equitable, politically correct, dangerous, or abhorrent, it is merely 'surprising' to a certain degree. A principled approach to science involves Bayesian model selection (originally due Jeffreys (1939)), which in practice may involve the easy to calculate approximation the Bayesian information criterion (BIC) (Schwarz 1978), followed by Bayesian model averaging.

Some policy decisions should depend on our degree of altruism. For example, economics can not explain inheritance, but science can, the money follows the genes. As another example, national governments have a duty to act in the interests of their citizens, but need a policy regarding giving aid to other nations. Using a gene-based biological approach, Salter (2006) estimates that the relative investment that individuals allocate to their self is 70%, their offspring 20%, their ethny 7% and humanity 3% (the numbers are merely indicative). This account is descriptive, but as we cannot transcend our genes (Moxon 2010), policy decisions should accommodate our innate altruism.

How much do we care about the future? If we wish to perform a cost-benefit analysis on a future public sector project, we must choose a discount rate that reflects society's preference for present benefits over future benefits. But how should one determine the social discount rate? Thus far, philosophy and economics have failed to come up with any consensus, so I defer to science, and take a bottom-up evolutionary approach. Although humans are simply vehicles that have evolved as if to help ensure that their genes survive in perpetuity, all that is required of individuals is that they are motivated to reproduce, so we seek to maximize gene replication within our lifetime, but not beyond. During a lifetime, generally the risk that a reward will not be available decreases as one approaches the time that the reward is expected, which leads to a hyperbolic discount function. Again, this account is descriptive, but as we cannot transcend our genes, a prescriptive social discount rate must accommodate our motivational set, so optimally coincides. An individual's discount function is hyperbolic and reaches 100% at the end of their lifetime. An equitable social discount function should average the population's individual discount functions. Such prescriptive myopic behaviour is consistent with both reality and the human race prospering in perpetuity. The social discount rate is applied to future utilities.

From the field of economics, *expected utility theory* (Bernoulli 1738; von Neumann and Morgenstern 1944; Bernoulli 1954) is a normative model of decision making under risk. Expected utility theory states that when making decisions under risk people should choose the option with the highest utility, which is the sum of the products of the utility of each outcome and its respective probability. When making policy decisions, we must choose a suitable utility function. Let us consider policy making at the national level. As stated above, we have evolved 'as if' reproduction is the sole goal for which human beings were 'designed', and everything else is a means to that end. Individuals are motivated to maximize their reproductive fitness via intra-sexual competition, which, at least for males, is well accommodated by competitive free markets, and free markets generate wealth. Working backwards, GDP may be considered a proxy for the well-being of a nation. I therefore propose that GDP at least makes a good starting point for a utility function. In the economic sense, the existence of externalities compromises overall social utility, so in practice, as an artefact of maximizing utility, public policy would seek to internalize any externalities.

By way of example, let us consider climate change mitigation. Climate sensitivity is a measure of how responsive the temperature of the climate system is to a change in the radiative forcing, and is usually expressed as the temperature change associated with a doubling of the concentration of CO_2 in the Earth's atmosphere. The first task is to determine the probability density function of climate sensitivity. Next, one must determine our utility function, GDP, for different levels of emissions, a drastic cut in emissions may harm the wealth of a nation, whilst an increase in emissions will lead to greater global warming which will compromise global GDP in the future. The utility function should discount the future according to the social discount rate, and our degree of altruism should dictate the degree to which we consider the utility of other nations.

According to Wikipedia, 'The *precautionary principle* states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is *not* harmful falls on those taking the action.' As scientists, we should not be bound by any principles outside those required for conducting science, but does the precautionary principle make sense? The French mathematician and astronomer Pierre-Simon Laplace asserted that 'the weight of evidence for an extraordinary claim must be proportioned to its strangeness', in other words, a more surprising hypothesis requires more evidence, and Bayes' theorem makes this explicit. In fact, the present-day form of Bayes' theorem is actually due to Laplace, Thomas Bayes only proved a special case. For example, it is known with certainty that CO_2 is a greenhouse gas and that levels of anthropogenic CO_2 in the atmosphere are increasing. So, a priori, it would be surprising if anthropogenic CO_2 was *not* contributing to global warming. This puts the onus on the climate sceptics. When hypotheses affect our utility, the expected utility hypothesis informs us that we should seek to maximize the sum of the products of the utility and the probability. Therefore the probabilities should be multiplied by the utility associated with each cost/benefit to determine the best course of action. So, if mitigating anthropogenic global warming has an associated cost, economically, the onus may move towards the proponents of anthropogenic global warming. This is consistent with the precautionary principle. Note the reversal of the onus of weight of evidence as we move from the science to policy, this is a source of some of the antagonism and confusion between the consensus view and the sceptics. It makes no sense to be a climate sceptic, but a lot of sense being a climate change mitigation sceptic.

References

AYACHE, Elie, 2010. *The Blank Swan: The End of Probability.* Chichester: Wiley.

BERNOULLI, Daniel, 1738. Specimen theoriae novae de mensura sortis. *Comentarii Academiae Scientiarum Imperialis Petropolitanae*, **5**, 175–192.

BERNOULLI, Daniel, 1954. Exposition of a new theory on the measurement of risk. *Econometrica*, **22**(1), 23–36. English translation of Bernoulli (1738) by Louise Sommer.

de FINETTI, Bruno, 1937. La prévision: Ses lois logiques, ses sources subjectives. *Annales de l'Institut Henri Poincaré*, **7**(1), 1–68. Translated into English as 'Foresight: Its logical laws, its subjective sources' in H. E. Kyburg, Jr and H. E. Smokler, eds. *Studies in Subjective Probability.* New York: Wiley (1964), pp. 93–158.

HUME, David, 1739–1740. *A Treatise of Human Nature: Being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects.* Oxford Philosophical Texts. Oxford: Oxford University Press. Edited by Norton, D. F. and Norton, M. J., published 2000.

JEFFREYS, Harrold, 1939. *Theory of Probability.* Oxford: Oxford University Press. Third ed., Oxford Classic Texts in the Physical Sciences, 1998.

LEWIS, David, 1980. A subjectivist's guide to objective chance. *In*: Richard C. JEFFREY, ed. *Studies in Inductive Logic and Probability. Volume II.* Berkeley: University of California Press, Chapter 13, pp. 263–293.

MOXON, Steve, 2010. Culture *is* biology: Why we cannot 'transcend' our genes—or ourselves. *Politics and Culture*, **1**.

SALTER, Frank, 2006. *On Genetic Interests: Family, Ethny, and Humanity in an Age of Mass Migration.* New Brunswick, NJ: Transaction Publishers. Originally published: Frankfurt am Main: Peter Lang Publishing, 2003.

SCHWARZ, Gideon, 1978. Estimating the dimension of a model. *The Annals of Statistics*, **6**(2), 461–464.

TALEB, Nassim Nicholas, 2010. *The Black Swan: The Impact of the Highly Improbable.* Second ed. New York: Random House Trade Paperbacks.

van FRAASSEN, Bas C., 1984. Belief and the will. *The Journal of Philosophy*, **81**(5), 235–256.

van FRAASSEN, Bas C., 1995. Belief and the problem of Ulysses and the sirens. *Journal Philosophical Studies*, **77**(1), 7–37.

von NEUMANN, John, and Oskar MORGENSTERN, 1944. *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.