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Fallacies in Scenario Reasoning

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Abstract

Abstract. Policy-makers frequently face substantial uncertainties and are required to cope with alternative scenarios that depict possible future developments. This paper argues that scenario reasoning is prone to suffer from characteristic mistakes. Probabilistic fallacies quantify uncertainties in an illegitimate way. Possibilistic fallacies systematically underestimate the full range of uncertainty, neglect relevant possibilities or attempt to represent a space of possibilities in an oversimplified way. Decision-theoretic fallacies, finally, fail to take the full range of uncertainties into account when justifying decisions, or misinterpret possibility statements by assigning them a special decision-theoretic meaning.
Keywords. scenario; possibility; great uncertainty; decision-making; fallacy

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Contents

1 Introduction

Most policy decisions have to be made in face of uncertainties about the options' outcomes. Standard expected utility models may be relevant and interesting from a theoretical point of view – yet the predictive uncertainties and the normative value of possible outcomes can rarely be quantified in a reliable way, which severely restricts the legitimate use of expected utility theory in scientific policy advice (Sahlin 2012). In response to this diagnosis, scholars from economics, decision theory, psychology and philosophy have investigated procedures of rational decision making that can cope with „deep," unquantifiable predictive or normative uncertainties; Hansson and Hadorn (2016a) comprehensively characterize such situations, subsuming them under the notion of „great uncertainty."

A major feature of decision making under great uncertainty is that it copes with scenarios (or „projections"). Scenarios, according to this paper's terminology, depict future developments which are considered to be possible. Arguing with possibilities in the context of decision making poses various problems. The pitfalls of scenario reasoning will be identified and discussed in this paper. It is supposed to show how one must not reason in situations of great uncertainty. Clearly, such negative advice is of limited help unless it is complemented by positive instructions on how one should reason. But the constructive task gœs beyond the scope of this text – I will merely highlight Bradley and Steele (2015) and the relevant chapters of The Argumentative Turn in Policy Analysis (namely Hansson 2016; Brun and Betz 2016; Betz 2016), which in turn refer to further literature.

Scenario reasoning in decision making contexts can be divided into two categories: (i) argumentation in favour of predictive statements („x, y and z are possible outcomes of that policy option", „the set X contains all possible outcomes of that option", „outcome x is more plausible than outcome y"); (ii) argumentation, based on scenarios, in favour of prescriptive conclusions, which state that some course of action is permissible or obligatory. Both sorts of reasoning have their own ‚logic' and hence go along with specific pitfalls. Section 3 and 4, re (i), discuss the potential mistakes in predictive argumentation while Section 5, re (ii), investigates common errors in practical argumentation. With a clear focus on scenarios, our discussion supplements and elaborates Hansson's broader analysis of fallacious reasoning under great uncertainty (Hansson 2016). Before we scrutinize reasoning errors that involve scenarios, however, we shall have a closer look at the notion of a fallacy in the following section.

2 A Note on Fallacies

In a very general sense, one commits a fallacy whenever one makes a mistake in reasoning. We use the notion of a fallacy, however, to refer more specifically to errors in drawing inferences. An argument is fallacious if and only if it is intended to be, but in fact is not valid, i.e. its premisses don't entail its conclusion.

(Example 1) The following argument is fallacious.

1. Socrates committed suicide only if he wasn't murdered.
2. He wasn't murdered.
3. **Thus:** Socrates committed suicide.

Its conclusion dœsn't follow from the premisses.
(Although both conclusion and premisses are true.)

Many arguments which are wrongly assumed to be valid realize characteristic patterns. That allows us to categorize fallacious arguments (tokens) by means of argument schemes, or fallacies (types).

(Example 1, cont'd) The argument realizes the following pattern,
where p and q represent sentences.

1. p only if q
2. q
3. **Thus:** p

This scheme is called „affirming the consequent."

So fallacies represent argument schemes that are not correct (which means that it is not the case that every instantiation of that scheme is a valid argument). Caveat: An instantiation of a fallacy may however represent a valid argument, because one and the same argument can conform to various patterns in the same time.

(Example 1, cont'd) An argument which realizes the following pattern,
where p and r represent sentences, instantiates „affirming the consequent."

1. p only if (non-r and (r or p))
2. (non-r and (r or p))

3 **Thus:** p

But it is valid nonetheless, because the conclusion follows deductively from (2).

To say that an argument with conclusion C is fallacious dœs not imply any of the following:

- The conclusion C of the argument is false.
- One of its premisses is false.
- There is no valid argument which comprises, besides further assumptions, the premisses of the fallacious argument and successfully backs its conclusion C.

As the last point indicates, fallacious arguments can typically be repaired by modifying premisses or by introducing additional premisses. Whether the modified argument is sound, however, hinges on these novel premisses. The fact that an argument cannot be reconstructed without adding implausible additional premisses indicates that the argument is fallacious.

(Example 1, cont'd) The original, fallacious argument can be repaired by modifying premiss (1).

1. Socrates committed suicide if and only if he wasn't murdered. (Equivalently: Either Socrates was murdered or he committed suicide.)
2. He wasn't murdered.
3. **Thus:** Socrates committed suicide.

The modified argument is valid, but premiss (1) has been significantly strengthened (being now an empirical statement) and it depends on the context whether it can be reasonably maintained.

In the remainder of this paper, we will present, albeit in an informal way, types of fallacies that are frequently committed in the context of scenario reasoning and illustrate them with concrete examples (i.e. fallacious arguments).

3 Probabilistic Fallacies in Scenario Reasoning

The probabilistic fallacies I discuss represent special cases of Hansson's Tuxedo fallacy (Hansson 2009), that is the mistake to proceed as if reliable probability estimates were always available.

3.1 Frequency Fallacy

Scientific assessments which make use of multiple models play an increasingly important role in scenario analysis. But it is fallacious to infer probability forecasts from multi-model ensembles (such as ensembles of climate models, or of energy models) by interpreting (weighted) relative frequencies of model results as probabilities.
Why is it fallacious? The argument assumes that (a priori) all models can be treated as equally likely (principle of indifference). But the principle of indifference is unjustified (van Fraassen 1989, chap. 12). In addition, the argument wrongly presumes that the models in the ensemble either span the whole range of possibilities or that the ensemble represents a random sample, drawn from the space of possible models. Both assumptions are also unwarranted (see also Knutti et al. 2010; Parker 2010). (If the argument is reconstructed in Bayesian terms, these two issues correspond to the problem of the prior and the problem of assessing the catch-all hypothesis, respectively.)

> (Example 2) In a meta-study, Krey and Clarke (2011) investigate 162 global energy scenarios in order to estimate the mitigation potential and costs of renewable energies. Instead of considered the 162 scenarios as mere possibilities, the authors infer, from the scenario ensemble, a probabilistic conclusion and commit the frequency fallacy:
> „Hence, although there is no obvious silver bullet, there is an indication that some renewable energy sources are more likely to play an important role than others." (p. 15; my emphasis)
> The IPCC however, in its methodologically percipient Special Report on Renewable Energy Sources and Climate Change Mitigation, makes use of Krey and Clarke's 162 scenarios in a cautious way and without committing the frequency fallacy (Fischedick et al. 2011).

3.2 Guru Fallacy

It is common practice to quantify uncertainties by means of so-called expert elicitations (O'Hagan and Oakley 2004). But it is fallacious to infer probability statements from alleged expert judgements in the absence of warrants for case-specific expert proficiency.
Why is it fallacious? Subjective degrees of belief, which are elicited, are not (necessarily) empirically constrained. Even worse, expert degrees of belief frequently don't satisfy probability axioms and are hence incoherent in a Bayesian sense (see Baron 2008, 137–160). In short, the argument treats experts as gurus and not as fallible beings with limited – potentially no – knowledge of a specific issue; it ignores that, facing a peculiar question, even our best experts might have no clue.

(Example 3) Expert elicitations have been used in climate science in order to probabilistically predict future climate change, in particular to estimate climate sensitivity (i.e., global equilibrium warming in response to a doubling of the atmospheric CO2 concentration), a potential future shutdown of the thermohaline circulation (i.e., the global system of ocean currents, which transports in particular vast amounts of warm water into the North Atlantic), and the contribution of polar ice sheets to sea level rise (cf. Morgan and Keith 1995; Zickfeld et al. 2007; Bamber and Aspinall 2013 respectively). These studies, however, don't show that the scientists who are questioned really possess a sufficiently broad range of experience in order to estimate the probabilities in question in a reliable and correct way. That's why they commit the guru fallacy. In fact, one of the studies finds that the experts' degrees of belief are not even coherent (Zickfeld et al. 2007).

4 Possibilistic Fallacies in Scenario Reasoning

4.1 One Baseline Fallacy

In policy analysis, the consequences of policy options are typically compared to a reference („business as usual“, or baseline) scenario. Now, under great uncertainty, it is fallacious to assess policy options with respect to a single reference scenario only.
Why is it fallacious? Under uncertainty, not only specific policy outcomes but the future development that results if no policy is implemented is uncertain, too. By considering only one baseline scenario, one ignores this uncertainty and effectively pretends to be able to make accurate deterministic forecasts. (Note however that this sort of argumentation ceases to be fallacious as soon as one explicitly assumes, and has even reason to assume, that the consequences of „business as usual“ policy can be predicted with certainty. Relying on a single baseline scenario is, in this particular case, legitimate.)[1]

> (Example 4) Before the German federal government eventually decided to opt out of nuclear energy after the Fukushima accident, it adopted, in 2010, a national energy plan („Energiekonzept“) which foresaw to prolong the operation of existing nuclear power plants. As part of the preparation of this policy proposal, three leading research institutes were commissioned to compile an assessment report, which investigates alternative options for extending the lifetime of nuclear power plants in view of macrœconomic effects and climate policy targets (Prognos, EWI, and GWS 2010). Yet the study compares the alternative policies in view of a single reference scenario only, which implicitly assumes that the effects of not extending the lifespan can be precisely and accurately predicted. The authors hence commit the one baseline fallacy.

4.2 Ceteris Paribus Fallacy

The one baseline fallacy can be avoided by interpreting scenario studies which rely on a single reference scenario along the following lines: These studies arguably don‘t deliver a full range of possibilities, but since the policy scenarios only differ from the reference scenario in view of implementing a certain policy measure, such studies determine at least relative effects (tendencies) of policies, which allow one to compare policies ceteris paribus, i.e. as long as everything else is kept constant. However, it is fallacious to infer from the qualitative or quantitative differences between the policy scenarios on the one side and the reference scenario on the other side a supposedly stable causal effect of the policy options, which will ensue independently of whether the reference scenario actually holds or not.
Why is it fallacious? The argument assumes that the causal effect of a policy is independent of the reference scenario. But that is of course an unwarranted assumption. Even the trends (in variables of interest) a policy gives rise to will in general depend on the circumstances under which the policy is implemented. So scientific assessments with one baseline scenario don‘t even reliably identify the directions of the changes policies will give rise to (see also Betz 2006, 113–116).

1 I owe this point to an anonymous reviewer.

(Example 5) Dieckhoff (2015, 160–163) shows that it is common for energy system modelers to interpret the differences between policy scenarios on the one side and the baseline scenario on the other side as robust qualitative effects of the policies under consideration. This interpretation avoids the one baseline fallacy, but it suffers from the ceteris paribus fallacy.

4.3 Reduction to Extremes Fallacy

Scientific reports which assess policy options under great uncertainty frequently only consider a handful of (extreme) scenarios which are supposed to represent the range of possibilities. But, as Voigt (2016) explains in detail, it is fallacious to infer properties of the entire space of possibilities from a few extreme scenarios only (instead of systematically sampling the space of possibilities).
Why is it fallacious? In general, a multidimensional (as opposed to a one-dimensional) space of possibilities can't be ‚spanned' by a handful of scenarios. A topologically complex set cannot be reduced to its extremes. Besides, extreme input scenarios (for exogenous variables) don't necessarily correspond to extreme output scenarios (concerning endogenous variables).

(Example 6) The federal regulatory agency which supervises the expansion of the German electricity grid (the „Bundesnetzagentur") stipulates that the planning should be based on four scenarios only, including two extreme ones, which are supposed to cover the whole bandwidth of probable energy-economic developments (Bundesnetzagentur 2012). The planners hence commit the reduction to extremes fallacy. If, for example, a policy option turns out to yield acceptable outcomes under all four scenarios considered by the Bundesnetzagentur, that dœs not guarantee that its effects are acceptable under any possible future development.

4.4 Verificationist Fallacy

It is fallacious to infer from a range of scenarios which have positively been established as possible (which means that they are shown to be consistent with current scientific understanding) that scenarios outside that range are impossible (and hence irrelevant). Taleb (2010, 93) describes a version of this fallacy, namely the conflation of a situation where there is no evidence for the possibility of P with a situation where there is evidence against the possibility of P („mistaking absence of evidence (of harm) for evidence of absence"), as „the mother of all harmful mistakes." (See also Shue 2010)
Why is it fallacious? Possibility statements don't imply that some hypothetical development is inconsistent with what we know, but only the latter would demonstrate that the respective development is actually impossible. The argument seems to rely on a false dualistic assumption: what is not shown to be possible is impossible (cf. Betz 2010).

(Example 7) In its third assessment report, the IPCC has determined the range of possible future sea level rise exclusively on the basis of climate model simulations (IPCC 2001). As a consequence, only the verified possibilities have been communicated and the so-called non-falsified possibilities, i.e. those for which we currently lack evidence, have been ignored. This instance of a verificationist fallacy is especially striking as it was clear that the climate models used to generate the range of scenarios didn't represent a key causal mechanism (notably the melting of polar ice sheets), which meant that the uncertainties were systematically underestimated (Betz 2009). The methodological mistakes have been uncovered in the ensuing scientific debate (Schubert et al. 2006; Rahmstorf 2007; Stainforth et al. 2007) and the IPCC now mentions robust upper bounds of sea level rise in addition to model projections (Church et al. 2013).

4.5 Ignoring Surprise Fallacy

It is fallacious to infer that some state-of-affairs S is impossible from the mere fact that every articulated hypothesis according to which the state-of-affairs S pertains has been successfully refuted.
Why is it fallacious? The argument would be fine if it could be safely assumed that we have actually considered all possible hypotheses. But that need not be the case, there could be so-far-unarticulated hypotheses (unknown unknowns) and some of these might be consistent with the state-of-affairs S! The fact that we haven't thought about some scenario dœsn't mean that it is impossible.

(Example 8) During the planning and construction of CERN's Large Hadron Collider (LHC) in Geneva, the hypothesis that the LHC generates stable microphysical black holes which eventually accrete the Earth has been seriously discussed (Blaizot et al. 2003; Clery and Cho 2008). The LHC Safety Assessment Group argued against the possibility of this state of affairs by claiming that there is no consistent microphysical scenario in which microscopic black holes are stable and accrete matter (Ellis et al. 2008). The LHC is presumably safe. Yet at closer inspection, the argument turns out to be fallacious: maybe a microphysical scenario which allows for stable, matter-accreting black holes has simply not been articulated so far.

4.6 Trusting the Model Blindly Fallacy

Scenarios are frequently established by means of simulations, based on a sophisticated model (e.g. a climate model or a model of the energy system). But it is fallacious to infer that some future development is possible merely because it has been obtained as a model result.
Why is it fallacious? Only if the model itself plus the parameter values, the boundary conditions and the initial conditions, which are used to derive the scenario, are collectively consistent with current scientific understanding (background knowledge) – only if this holds dœs the simulation establish that its results are consistent with background knowledge, too. Given the plethora of idealizing and unrealistic assumptions built into scientific models, that necessary condition seems rather implausible (Betz 2010).

(Example 9) This fallacy is abundant in scenario reasoning and scientific policy advice under great uncertainty. It seems that neither climate, nor energy system nor macrœconomic models are suited to establish possible consequences (scenarios) of alternative policy options (pace, e.g.,

> IPCC 2011; Collins et al. 2013; European Commission 2011). That's because all these models make use of unrealistic assumptions which are known to be wrong (e.g. Pahle et al. 2012). (And in addition, these unrealistic assumptions cannot be justified as means to make the models predictively successful.)

This fallacy appears to be devastating for state-of-the-art, model-based scenario analysis. It raises the question whether complex simulation models have a role to play in scenario reasoning at all (cf. Grüne-Yanoff 2014; Betz 2015).

5 Decision-theoretic Fallacies in Scenario Reasoning

5.1 Picking the Scenario Fallacy

In decisions under great uncertainty, policy-makers typically face a huge variety of possibilities which may be difficult to absorb. Hence a desire to „reduce" the uncertainty. Yet it is fallacious to make and to justify a decision by choosing a single outcomes-scenario from a possibility range and neglecting the others in the further decision-making process. This mistake is a special case of the „cherry picking fallacy" (Hansson 2016).

Why is it fallacious? The underlying decision principle is – depending on how it is spelled out – empty or self-refuting. If the scenario range is only sufficiently diverse, any recommendation whatsœver – and hence even contrary conclusions – can be derived by focusing on a suitable scenario.

> (Example 10) In 2015, the German Federal Government had appointed a cooperate auditor to verify whether the reserves accumulated by German energy providers will match the future costs of dismantling their nuclear power stations (cf. Weingartner 2015). The report issued by the auditor considered different scenarios in order to account for general uncertainties in future discount rates and so-called nuclear-specific construction costs. It found that the overall costs for dismantling the nuclear infrastructure will range from 29.9, to 77.4 billion Euro, while the energy providers' reserves amount only to 38.3 billion Euro. Now, the Federal Minister for Economic Affairs and Energy interpreted the report as saying that energy providers have built up sufficient reserves to cover future costs. This interpretation obviously ignores the vast range of uncertainty, focuses on a single (convenient) scenario and hence commits the picking the scenario fallacy.

5.2 Certainty Equivalence Fallacy

Decision-makers might also be tempted to „reduce" uncertainty in view of the perceived plausibility of the various scenarios. But it is fallacious to justify a decision, or a recommendation, by pretending that the most plausible, or most likely outcomes-scenario from a possibility range will certainly come true. This type of reasoning is closely related to the fallacy of picking the scenario; it is also built into some macrœconomic growth models with the aim of making them mathematically tractable (Romer 1996, 246–7).

Why is it fallacious? First of all, under great uncertainty, there is by definition no reliable probabilistic information against which a scenario could be singled out as the most likely one. Any choice of a scenario is purely subjective and arbitrary. If, however, reliable probability forecasts were available, then the decision principle of certainty equivalence contradicts expected utility maximization; even worse, it is totally insensitive to known and quantified uncertainties and hence highly counter-intuitive.

> (Example 11) The German Council of Economic Experts uses to provide single point forecasts of economic growth in its annual reports, although the advisory board is well aware of the huge uncertainties of such predictions (which the reports discuss in detail). But it defends the single point forecast explicitly as the most likely macrœconomic development (Sachverständigenrat zur Begut-

achtung der gesamtwirtschaftlichen Entwicklung 2014, 104). By suggesting that policy decisions under great uncertainty can be made in view of the most likely scenario only, the German Council of Economic Experts is thus committing, year after year, the fallacy of certainty equivalence.

5.3 Conflation of Necessary and Sufficient Conditions Fallacy

A neat justification of policy measures consists in showing that these measures are required to attain some policy goals. But it is fallacious to infer that bringing about some feature (a policy measure) is required for reaching a policy goal from the fact that the feature (the policy measure) figures in all investigated scenarios in which the policy target is attained.
Why is it fallacious? The argument fails to consider that there might be further scenarios in which the policy goals are attained but in which the specific feature (policy measure) dœs not obtain. The underlying point is that there is no reason to assume that the scenarios set up so far exhaust the set of all possible future developments. The conflation of necessary and sufficient conditions in scenario reasoning is hence closely related to the verificationist fallacy.
At best, the identification of scenarios in which policy goals are attained by certain measures shows that these measures are (possibly, given the right circumstances) sufficient to attain the goal.

> (Example 12) Analysing Greenpeace's comprehensive energy [r]evolution scenario (Voigt 2014a) as well as the scientific assessment of energy policies which accompanied the European Commission's Energy Roadmap 2050 (Voigt 2014b), Voigt discovers that these studies (mis-)interpret the finding that all scenarios in which ambitious climate policy targets are attained exhibit a specific feature, say drastic reductions in energy demand, as saying that the specific feature is necessary in order to attain the policy goals in question. As Voigt notes, this is obviously mistaken because the studies don't pretend to provide a comprehensive assessment of all possible future developments. The authors hence commit the fallacy of conflating necessary and (possibly) sufficient conditions.

5.4 Possibility Means Feasibility Fallacy

Debates about alternative goals for policy-making must pay close attention to the question whether and at what costs these goals can be reached. Proponents of policy targets will argue that the goals are ‚realistic' and try to establish the goals' achievability. Yet, it is fallacious to infer that it is feasible to reach a policy target on the basis that there is a scenario in which the target is attained.
Why is it fallacious? There is a fundamental difference between (i) x being possible (i.e., being consistent with current knowledge) and (ii) someone being able to bring about x. It's possible that the number of sun-like stars in our galaxy is even, but that's nothing anybody can bring about or achieve.
On the linguistic surface, however, that difference get's frequently blurred, as we use words like „can" or „possible" to denote both what is possible and what is achievable („it's not possible for me to be there in time", „the company can do better, it's possible to improve results", „I can do that", „it can be true that …"). Now, more specifically, the argument is fallacious because there might be further circumstances

(not considered in any scenario so far) which prevent decision-makers from reaching the policy target by means of any measure whatsœver. So, at best, the argument shows that it is possible that the policy goals will be achieved (but besides doing the right things this requires also luck).

> (Example 13) In 2011, the WWF published a global energy scenario according to which the world economy switches to 100% renewables by the mid of the century (World Wide Fund for Nature 2011). The scenario is supposed to establish that „switching to a fully renewable energy supply by 2050 is achievable" (p. 23) and that it is „possible to secure a fully renewable, sustainable energy supply for everyone on the planet by 2050." (p. 23) WWF „believes that it is a goal we can and must achieve." (p. 23) But the authors admit in the same time that the report only presents a scenario „which demonstrates that it is technically possible to achieve almost 100 per cent renewable energy sources within the next four decades." (p. 11; my emphasis) What are we to make of this? The report shows that decarbonisation of the global energy system is consistent with current knowledge, and feasible under many favourable assumptions. But that dœsn't entail that policy-makers (or any other agents) are able to bring about these favourable assumptions. Admittedly, WWF concedes that „challenges" lie ahead. Still, in presenting a mere possibility as something that can be achieved, WWF commits the possibility means feasibility fallacy (or is on the brink of doing so).

6 Conclusion

This paper has argued that scenario reasoning is prone to suffer from various mistakes. Probabilistic fallacies quantify uncertainties in an illegitimate way. Possibilistic fallacies systematically underestimate the full range of uncertainty, neglect relevant possibilities or attempt to represent a space of possibilities in an oversimplified way. Decision-theoretic fallacies, finally, fail to take the full range of uncertainties into account when justifying decisions, or misinterpret possibility statements by giving them a special decision-theoretic meaning.

Implicitly, all these reasoning patterns have been diagnosed as fallacious on the background of a theory of correct possibilistic reasoning and decision-making under great uncertainty. Such a positive theory, as for example introduced in The Argumentative Turn in Policy Analysis (Hansson and Hadorn 2016b), certainly has to complement our negative account of reasoning errors in order to help decision-makers and stakeholders to improve the way they reason with scenarios.

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