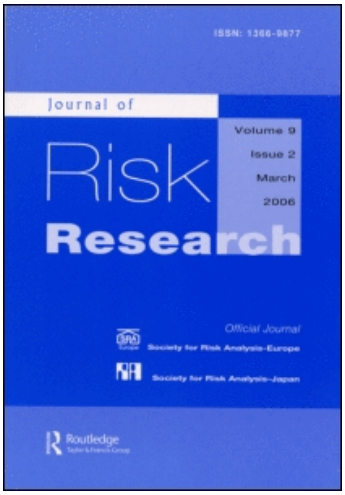

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Five charges against the precautionary principle

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Abstract

We defend the precautionary principle against five common charges, namely that it is ill-defined, absolutist, and a value judgement, increases risk-taking, and marginalizes science. We argue, first, that the precautionary principle is, in principle, no more vague or ill-defined than other decision principles and like them it can be made precise through elaboration and practice. Second, the precautionary principle need not be absolutist in the way that has been claimed. A way to avoid this is through combining the precautionary principle with a specification of the degree of scientific evidence required to trigger precaution, and/or with some version of the *de minimis* rule. Third, the precautionary principle does not lead to increased risk-taking, unless the framing is too narrow, and then the same problem applies to other decision rules as well. Fourth, the precautionary principle is indeed value-based, but only to the same extent as other decision rules. Fifth and last, the precautionary principle is not unscientific other than in the weak sense of not being exclusively based on science. In that sense all decision rules are unscientific.

KEY WORDS: *de minimis*, precautionary principle, risk-tradeoff

1. Introduction

In 1999 Gail Charnley, then president of the Society for Risk Analysis, declared in the Society's newsletter that 'the precautionary principle is threatening to take the place of risk analysis as the basis for regulatory decision making in a number of places, particularly in Europe' (Charnley, 1999). Returning to the subject in the same forum in early 2000, she described risk analysis as 'a discipline under fire', threatened by a

> serious, growing, antirisk-analysis sentiment that is challenging the legitimacy of science in general and risk analysis in particular . . . And what is it being replaced with? The so-called precautionary principle or the "better-safe-than-sorry" approach.

She sees here

> just the newest skirmish in the age-old battle between science and ideology, between evolution and creationism. It's about religion. In one corner, we have risk analysis – the practice of using science to draw conclusions about the likelihood that something bad will happen

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– and in the other corner, we have the belief that instead of science, the precautionary principle will somehow solve all our problems (Charnley, 2000).

These statements from a leading risk analyst reflect a rather widespread view that the precautionary principle is in disagreement with a scientific approach to risk assessment and risk management. A survey of the literature shows that critics have declared that the precautionary principle:

- is ill-defined (Bodansky, 1991)
- is absolutist (Manson, 1999)
- leads to increased risk-taking (Nollkaemper, 1996)
- is a value judgement or an 'ideology' (Charnley, 2000)
- is unscientific or marginalises the role of science (Gray and Bewers, 1996).

In this short essay, we intend to defend the precautionary principle against these charges, and in particular to show that it *is* compatible with science. In section 2, we briefly review what is meant by the precautionary principle. In section 3, we respond to each of the five cited charges against this principle, and in section 4 we conclude by noting that our defence of the precautionary principle should be encouraging for its proponents, but it should also urge them to refine their principle.

2. What is the precautionary principle?

There is considerable disagreement as to what the precautionary principle means, a problem which we discuss more fully in section 3.1. Its origins, however, can be traced back at least to German environmental legislation from the 1970s (Sandin, 1999). The basic message of the precautionary principle, in the versions discussed in the present essay, is that on some occasions, measures against a possible hazard should be taken even if the available evidence does not suffice to treat the existence of that hazard as a scientific fact.[1]

3. Meeting the charges against the precautionary principle

We can now return to the five major charges against the precautionary principle that were listed in section 1.

3.1. IS THE PRECAUTIONARY PRINCIPLE ILL-DEFINED?

It is often complained that the precautionary principle is vague or ill-defined. '[The precautionary principle] is too vague to serve as a regulatory standard', writes Daniel Bodansky (1991: 5; see also Bodansky, 1992). Two other authors claim that a version of the precautionary principle used in the context of marine pollution 'poses a number of fundamental problems', as the logic of the principle is unclear and its key terms are not defined (Gray and Bewers, 1996: 768). The fact that the precautionary principle has occurred in some important official documents (e.g. the Maastricht Treaty; see, for

[1] In fact, lack of full scientific evidence is a prerequisite for applying the principle. If scientific evidence *is* conclusive, we may of course demand measures to preclude harm, but that would be a case of prevention rather than precaution.

instance, Krämer, 2000: 16f and a recent EU communication, CEC, 2000) without explicit definition also fuels the perception that it is poorly defined. Furthermore, the fact that there is a number of different versions of the precautionary principle supports the impression that it – if it is even possible to speak of 'it' – is poorly defined.

This objection certainly poses a problem for proponents of the precautionary principle. In response, they might argue that lack of specificity is not unique to the precautionary principle and that the same objection can be raised against many other decision rules. Consider for instance a rule such as 'only perform those risk reductions that are scientifically justified', a rule which seems no less in need of specification than the precautionary principle (cf. Cameron and Abouchar, 1991: 23). However, both the relevance and the truth of this defence can be put in question. First, claiming that other decision rules are as ill-defined as the precautionary principle is a weak defence of the precautionary principle. It certainly does not support the view that any of these other rules should be replaced by the precautionary principle. Second, even if other decision rules are not *in principle* better defined than the precautionary principle, they might *in fact* be, in the sense that due to their long period of use there has emerged a substantial body of interpretations and practices that partly compensate for the lack of exact definitions. There are, for instance, governmental guidance documents and court cases that can be of help in interpreting these principles.

Thus, proponents of the precautionary principle should acknowledge that the absence of a clear definition is a problem. However, it is one that can be remedied. It is possible to specify more precise versions of the precautionary principle, that are more readily applicable than a general statement that a precautionary approach should be applied (Sandin, 1999 gives an indication of how this can be done).

We may begin with emphasizing the distinction between *prescriptive* and *argumentative* versions of the precautionary principle.[2] An argumentative version is found, for instance, in Principle 15 of the Rio Declaration (UNCED, 1993).[3] This version merely requires that 'lack of full scientific certainty shall not be used as a *reason* for postponing cost-effective measures to prevent environmental degradation' (italics ours). Thus, it is not a substantial principle for decisions, but a principle for what arguments are valid, i.e. a restriction on dialogue. In essence it says little more than that arguments from ignorance should not be used. Such arguments are generally regarded as trivially fallacious (Robinson, 1971; cf., however, Wreen, 1984 and Walton, 1992), and barring them from discourse does not seem very demanding. Thus, the philosophical interest of argumentative versions of the precautionary principle are rather limited. We will not dwell upon them here.

Prescriptive versions of the precautionary principle seem more prevalent in public and scholarly debate than argumentative ones, both among proponents of the precautionary principle (reflected for instance in the Wingspread Statement, see Raffensperger and Tickner, 1999) and its critics (e.g. Manson, 1999).[4]

[2] The distinction between prescriptive and argumentative versions of the precautionary principle is noted by Morris (2000: 1), who, however, terms them 'weak' and 'strong' versions. This terminology is, we believe, a less happy one, as the difference is one of kind rather than degree.

[3] This is briefly noted in Sandin (1999: 895). It might be pointed out that in the English version of the Rio Declaration, the term 'the precautionary principle' is not used. Instead, the phrase 'the precautionary approach' is used. However, the Swedish version, for instance, uses 'försiktighetsprincipen', i.e. the precautionary principle.

[4] It is interesting to note that the European Chemical Industry Council has moved from an action prescribing version of the precautionary principle (CEFIC, 1995) to an argumentative one (CEFIC, 1999).

As was shown in Sandin (1999), most prescriptive versions of the precautionary principle share four common elements or dimensions. These formulations can be recast into the following if-clause, containing the four dimensions: '*If* there is (1) a threat, which is (2) uncertain, *then* (3) some kind of action (4) is mandatory.' By paying attention to these four dimensions, the precautionary principle may be made more precise. Hence, in order to make the principle operational, the following four specifications have to be made as a first step.

1. To what types of hazards does the principle apply?
2. Which level of evidence (lower than that of full scientific certainty) should be required?
3. What types of measures against potential hazards does the principle refer to?
4. With what force are these measures recommended (mandatory, merely permitted, etc.)?

(For a further discussion of some of these issues, see Sandin, 1999, and Hansson, 1999a.)

Finally, interpretations of the precautionary principle are in fact emerging, albeit slowly. For instance, the recent EC communication (CEC, 2000), the broad lines of which were endorsed by the European Council's meeting in Nice, December 2000 (European Council, 2000: Annex III), is a modest step in this direction. The Commission notes that 'it would be wrong to conclude that the absence of a definition has to lead to legal uncertainty' (p. 10), and that '[t]he Community authorities' practical experience with the precautionary principle and its judicial review make it possible to get an ever-better handle on the precautionary principle' (*ibid.*).

To sum up, it must be admitted that the precautionary principle is to some extent poorly defined, and that it is even worse off than such competing decision rules for which there exists a body of interpretations and practical experience that can compensate for the lack of exact definitions. However, this can (and should) be remedied. The precautionary principle may be given more precise formulations, in the way indicated above. Interpretations of the precautionary principle are also beginning to emerge from practical experience.

3.2. IS THE PRECAUTIONARY PRINCIPLE ABSOLUTIST?

A further accusation against the precautionary principle is that it is absolutist or 'overly rigid' (Bodansky, 1992: 4). According to one author, '[i]n several treaties, the precautionary principle is formulated in absolutist terms. It stipulates that once a risk of a certain magnitude is *identified*, preventive measures to erase that risk are *mandatory*' (Nollkaemper, 1996: 73, italics ours). Of course, virtually every activity is associated with some risk of non-negligible damage. Therefore, under this interpretation the precautionary principle can be used to prohibit just about any human activity.

'Absolutist' here means, roughly, that the precautionary principle forces decision-makers to pay unreasonable attention to *extremely* unlikely scenarios. For an example, let us assume that there is an extremely small cancer risk associated with the food additive R&D Orange No. 17, say 1 chance in 10^{19}/70-year life. Now, since cancer is a non-negligible harm and we can produce food looking almost as tasty without using R&D Orange No. 17, an adherent of the precautionary principle ought to conclude, it seems, that the use of R&D Orange No. 17 must be prohibited because this substance

can cause cancer. However, this is absurd (the argument goes), since the cancer risk associated with R&D Orange No. 17 is *extremely* small and contributes almost nothing to the total cancer risk. Thus, the precautionary principle is 'absolutist' in the sense of being insensitive to scientific facts about the *probabilities* associated with different risks.[5] Hence, it is claimed, the precautionary principle would require us to prohibit everything that *might* be dangerous. A similar charge was raised by the National Association of Swedish Fishermen, in their comment on the suggested new Swedish Environmental Code. The fishermen held that the precautionary principle as applied to fisheries would mean that no fishing at all could be undertaken (Swedish Government, 1997: §481).

Under such a strict, absolutist interpretation of the precautionary principle, it would prohibit in principle *every* action. Since any action, in a sense, might have unforeseen catastrophic consequences (perhaps, due to the chaotic nature of causation, you will cause a new world war by taking a day off tomorrow, etc.), the action of carrying it out will be prohibited, and so will the action of *not* carrying it out. This objection was raised by McKinney (1996) and Manson (1999).

The argument from absolutism is clearly based on a misconstruction of the precautionary principle. The principle requires that actions be taken when there is lack of full scientific certainty. This, however, does not mean that precautionary measures are required when there is no particular evidence, scientific or other, of the presence of a possible hazard. Indeed, we have not been able to find any authoritative formulation or interpretation of the principle that supports such an extreme requirement. In fact, some documents explicitly demand that the possibility of harm at least should be identified (European Council, 2000: Annex III, §7).

Nevertheless, the argument from absolutism helps to put into focus one of the major specifications of the precautionary principle that was referred to in section 3.1: if full scientific proof is not required before precautionary action should be taken, then what is the required degree of scientific evidence? One obvious way of answering this question is to state a degree of evidence in qualitative terms, such as 'strong scientific evidence' or 'scientifically supported strong suspicions'. Admittedly, these phrases are not very precise, but they are not obviously less precise than many other phrases that legislators leave it to courts to interpret. It is not even clear that they are more difficult to interpret than phrases such as 'full scientific proof' or 'scientific certainty'. Today, most formulations of the precautionary principle lack such specification of the required degree of scientific evidence needed to trigger precautionary action. This is, for instance, the case with the formulations reviewed in Sandin (1999).[6] Needless to say, the development of such specifications is an essential part in the operationalisation of the precautionary principle.

Another way to deal with the problem of absolutism is to apply an adaptation of the *de minimis* principle prior to application of the precautionary principle. *De minimis* is a threshold concept. 'A de minimis risk level would . . . represent a cutoff, or benchmark, below which a regulatory agency could simply ignore alleged problems or hazards'

[5] This argument should not be confused with the claim that the precautionary principle pays too little attention to scientific findings in general, a claim to which we will return in section 3.5. Of course, we would never have known that R&D Orange No. 17 *might*, in very unlikely cases, cause cancer, if scientific research had not been carried out.
[6] There are rare exceptions, however. For instance, the Swedish Chemicals Legislation from 1985 required a 'reasonable scientific foundation' in order to trigger precautionary measures (Hansson, 1991). Cf. Hickey and Walker (1995: 448).

(Fiksel, 1987: 4).[7] The *de minimis* principle excludes scenarios with very small probabilities from consideration.[8]

Some proponents of this principle have suggested specific numbers for fixing a *de minimis* level (Flamm *et al.*, 1987: 89; Pease, 1992: 253; FDA, 1995). Others have claimed that probabilities are *de minimis* if and only if they cannot be scientifically detected, or distinguished from random effects in randomized studies (Suter *et al.*, 1995; Stern, 1996). (See Hansson, 1999b for a critical discussion.) None of these approaches are without problems. However, we will not go into the eminently difficult question of how to interpret and determine *de minimis* levels, but merely note that a proponent of the precautionary principle may very well – and perfectly consistently – apply the *de minimis* principle, but will expectedly use a lower probability limit than proponents of a non-precautionary approach.

It might be objected that applying some sort of *de minimis* principle requires quantitative risk assessments, something which the precautionary principle does not. Thus, the *de minimis* principle would require more information than the precautionary principle alone. This is true, but it need not be a problem. Applying the *de minimis* principle does not require that the probability of the undesired event can be determined. It only requires that it can be determined whether or not its probability is below a certain level. This is of course more information than the absolutist version of the precautionary principle requires, as it only requires that the event is possible, which in this case might be interpreted as saying that its probability is > 0. On the other hand, it is significantly *less* information than what the calculation of expected utility requires (i.e. a reasonable probability estimate).

There is also another problem. Some proponents of the precautionary principle explicitly see it as an alternative to risk-based decisions (Santillo *et al.*, 1999). Combining the precautionary principle with a *de minimis* rule, it might be argued, would mean moving the precautionary principle towards a risk-based approach, towards which certain proponents of the precautionary principle might be hostile. To this we can only reply that while this might make the precautionary principle less effective as a rhetorical device, it will probably make it more applicable as a decision rule.[9] Furthermore, we may also reduce the risk that the precautionary principle is used in a completely unreflected manner, something that might happen if the absolutist version is used as a guide for decision making.

3.3. DOES THE PRECAUTIONARY PRINCIPLE LEAD TO INCREASED RISK-TAKING?

Let us now turn to an argument stating that the precautionary principle leads to the imposition of new risks, since cautiousness in one respect often leads to incautiousness

[7] By *de minimis non curat lex* is meant the legal principle that courts of law should not concern themselves with trifles. The concept of '*de minimis* risk' was derived from this legal principle in the early 1980s. Originally, it was used by the US Food and Drug Administration (FDA) as a motive for not obeying the so-called Delaney Amendment, which prohibits the use of *all* carcinogenic food additives, including substances that only increase the cancer risk by a very tiny fraction (FDA, 1999; Blumenthal, 1990; Weinberg, 1985).

[8] In practice, *de minimis* is usually applied to the probability of certain outcomes, given that a certain alternative is implemented, such as the lifetime probability p of developing cancer, given that one has been exposed to a certain food additive. For analytical completeness, however, we might regard *de minimis* as applied to states of nature (the probability that nature is so constituted that the lifetime probability of developing cancer, given that one has been exposed to a certain food additive, is p).

[9] Cf. Cross (1996: 925): 'Rhetorically, the precautionary principle may prove quite useful to advocates of one particular policy or another. Pragmatically, the principle is destructive, even self-destructive.'

in another. This may come about directly – when precautionary measures themselves impose new risks – or indirectly – when precautionary measures are so costly that the resultant loss of wealth imposes risks. A clear example of when precautionary measures *directly* impose risks would be the use of pesticides in a developing country. Pesticides may be a threat to the environment, and, it can be argued that for reasons of precaution, they should not be used. But that would in some cases lead to an increased risk of crop failure and consequently of famine which, for reasons of precaution, should be avoided. Substitution of hazardous chemicals poses similar problems. If neurotoxic pesticides are not to be used, there is a possibility that we are driven to use substitute chemicals that might be less neurotoxic, but may instead be carcinogenic.[10] Less obvious, but no less important, is the possibility that precautionary measures *indirectly*, through economic mechanisms, impose risks.

> Risk driven regulation of one industrial sector under one treaty can be a perfect implementation of the precautionary principle, but can also consume resources that cannot be spent on equal or more serious risks in other sectors. (Nollkaemper, 1996: 91)

Another possible scenario might be that precautionary measures stifle technological progress, causing the loss of benefits that would otherwise have been available (for example, more and healthier food from genetically modified plants).

A similar argument has been raised against environmental regulations and, in fact, risk reduction efforts in general: there is a strong correlation between health and wealth; the richer you are, the healthier you are. 'Richer is Safer', as the title of Wildavsky's (1980) article aptly states it. (For formal, quantitative discussions of the problem, see Keeney, 1990; 1997.) Precautionary measures impose costs, and they might therefore in the end lead to worse effects than if they had not been carried out. Cross (1995) gives an enlightening review of this argument; see also Cross (1996). Another example can be found on the web site of the American Council on Science and Health:

> [I]f we act on all the remote possibilities in identifying causes of human disease, we will have less time, less money and fewer general resources left to deal with the real public health problems which confront us. (Whelan, 2000)

This argument is attractive and might seem troublesome for defenders of the precautionary principle. However, the problem does not depend on the precautionary principle itself but on the limited framing of the decision problem to which it is applied. When delineating a decision problem, one has to draw the line somewhere, and determine a 'horizon' for the decision (Toda, 1976). If the horizon is too narrow, then decisions will be recommended that are suboptimal in a wider perspective, and this applies irrespective of what decision rule is being used. If we apply expected utility maximization to, for instance, crop protection, seen as an isolated issue, then the decision with respect to pesticides may very well be different from what it would have been if we had applied the same decision rule to a more widely defined decision problem in which effects on nutrition and health are included. The same is true if we replace expected utility maximization by the precautionary principle, or, it might be added, any other decision rule.

Here, it must be admitted that the precautionary principle, used as a rhetorical device, might in fact tempt decision-makers to focus upon a single, conspicuous threat, while

[10] See Gray and Hammitt (2000) for a discussion of risk tradeoffs in pesticide substitution. On risk tradeoff analysis in general, see Graham and Wiener (1995).

disregarding countervailing risks. This, however, should not be a reason for abandoning the precautionary principle. Instead, it should urge us to apply the precautionary principle in a reasonable and reflected manner. Particularly, the precautionary principle should be applied also to the precautionary measures prescribed by the precautionary principle itself.

3.4. IS THE PRECAUTIONARY PRINCIPLE A VALUE JUDGEMENT?

Some critics of the precautionary principle have argued that it is a value judgement or an 'ideology' (Charnley, 2000), not a factual judgement. It is claimed that the precautionary principle merely expresses a subjective attitude of fear against risk taking, and therefore can neither be confirmed nor falsified by scientific studies. Since science only deals with factual truths, not subjective attitudes towards risk taking, the precautionary principle simply leaves no room for a scientific approach to risk analysis. Or so the story goes.

In order to appraise this argument, let us return to the central feature of the precautionary principle that was identified in section 2, namely that precautions are required in the absence of full scientific evidence. Hence, according to the precautionary principle, the level of evidence at which precautions should be taken is situated below the level of full scientific evidence. This is clearly a value judgement. However, the alternative standpoint, that the level at which precautions should be taken coincides with the level of full scientific evidence, is to no less degree a value judgement.

It should also be observed that the notion of 'scientific proof' may not, in itself, be as value-free as it is often thought to be. In a famous paper, Richard Rudner (1953) claimed that a decision whether or not to accept a scientific hypothesis must take into account not only the available empirical evidence but also the seriousness of the two possible types of mistakes: accepting an incorrect hypothesis and rejecting a correct one. In Rudner's own words:

> But if this is so then clearly the scientist as scientist does make value judgements. For, since no scientific hypothesis is ever completely verified, in accepting a hypothesis the scientist must make the decision that the evidence is sufficiently strong or that the probability is sufficiently high to warrant the acceptance of the hypothesis. Obviously our decision regarding the evidence and respecting how strong is 'strong enough', is going to be a function of the importance, in the typically ethical sense, of making a mistake in accepting or rejecting the hypothesis ... How sure we need to be before we accept a hypothesis will depend on how serious a mistake would be. (Rudner, 1953: 2)

It is certainly a matter of debate what types of values should be allowed to influence a decision to accept or not to accept a scientific hypothesis (Rudner, 1953; Churchman, 1956; Leach, 1968; Martin, 1973; Rooney, 1992; Valerioano, 1995). According to one view, only intrascientific, 'epistemic' values such as simplicity, usefulness in further inquiries, etc. should be allowed to have an influence. According to another view, moral values may also have a role in this type of decision. (For a discussion of these different views, see Martin, 1973.) At any rate, the intrascientific standards of scientific proof are based to a large degree on considerations of investigative economy. It would be a strange coincidence if the level of evidence that is appropriate according to these criteria always coincided with the level of evidence required for practical action.

The claim that the precautionary principle should not be applied, or in other words the claim that precautions should only be taken when full scientific proof of a hazard has been obtained, is value-based in essentially the same way as the precautionary principle itself. They are indeed both value-based on two levels. First, the very identification

> level of evidence necessary for action = level of evidence necessary for scientific proof

is a value judgment, based on moral values. Of course, the same applies to the inequality:

> level of evidence necessary for action < level of evidence necessary for scientific proof.

Second, the determination of the level of evidence required for scientific proof involves value judgements, based on epistemic and possibly also moral values. In summary, to the extent that the charge 'it is a value judgment' holds against the precautionary principle, it also holds against its rivals. Of course, different value systems may sometimes be in conflict. This is evident from the distinction between two types of errors in scientific practice. The first of these consists in concluding that there is a phenomenon or an effect when in fact there is none (type I error, false positive). The second consists in missing an existing phenomenon or effect. This is called an error of type II (false negative). According to the value structure system of pure science, errors of type I are in general regarded as much more problematic than those of type II. According to the value system of environmental decision-making, however, type II errors – such as believing a highly toxic substance to be harmless – may be the more serious ones (see also Hansson, 1999a and, e.g. Raffensperger and de Fur, 1999: 937).

3.5. IS THE PRECAUTIONARY PRINCIPLE UNSCIENTIFIC?

Finally, we can turn to what is one of the most worrying arguments against the precautionary principle, namely that it is 'unscientific' and 'marginalises the role of science' (Gray and Bewers, 1996).

According to the adherents of this view, the precautionary principle fails to pay enough respect to science, since it requires that precautionary measures be taken also against threats for which full scientific evidence has not been established. For instance, the use of a chemical substance can be prohibited by the precautionary principle even if we do not *know* whether it is (say) carcinogenic or not. And since many of the achievements of Western civilization during the past two millennia result from its success in applying scientific results, there are strong reasons to believe that decisions taken in this manner (i.e. without full scientific evidence) will be of a lower quality, leading to worse outcomes, than decisions based on full scientific knowledge.

In spite of its convincing first appearances, this argument breaks down as soon as sufficient attention is paid to its key term 'unscientific'. There are two meanings of this word. A statement is unscientific in what we may call the weak sense if it is *not based on* science. It is unscientific in what we may call the strong sense if it *contradicts* science. Creationism is unscientific in the strong sense. Your aesthetic judgements are unscientific in the weak but presumably not in the strong sense.

The precautionary principle is certainly unscientific in the weak sense, but then so are all decision rules – including the rule that equates the evidence required for practical measures against a possible hazard with the evidence required for scientific proof that the hazard exists.

On the other hand, the precautionary principle is *not* unscientific in the strong sense. A rational decision-maker who applies the precautionary principle will use the same type of scientific evidence (hopefully, the best evidence available), and assign the same relative weights to different kinds of evidence, as a decision-maker who requires full scientific evidence before actions are taken. The difference lies in the amount of such evidence that they require for a decision to act against a possible hazard. The scientific part of the process, i.e. the production and interpretation of scientific evidence, does not differ between the two decision-makers. This shows that the precautionary principle does not contradict science, and also that it does not marginalize science as a tool in decision-making (cf. e.g. Santillo and Johnston, 1999; Hansson, 1999a).

4. Conclusions

In this article, we have countered five common charges against the precautionary principle.

First, the precautionary principle is, in principle, no more vague or ill-defined than other decision principles. Like them, it can be made precise through elaboration and practice. This is an area where more work is urgently needed for proponents of the precautionary principle.

Second, the precautionary principle need not be absolutist in the way that has been claimed. A way to avoid this is through combining the precautionary principle with a specification of the degree of scientific evidence required to trigger precaution, and/or with some version of the *de minimis* rule.

Third, the precautionary principle does not lead to increased risk-taking, unless the framing is too narrow, and then the same problem applies to other decision rules as well. Nevertheless, as the precautionary principle might deceive decision-makers into simplistically focusing upon a single, conspicuous threat while ignoring countervailing risks, it is important that the precautionary principle is applied in a reasonable manner. In particular, the precautionary principle should be applied also to the precautionary measures prescribed by the principle itself.

Fourth, the precautionary principle is indeed value-based. But so are all decision rules, and the precautionary principle is only value-based to the same extent as other decision rules.

Fifth and last, the precautionary principle is not unscientific other than in the weak sense of not being exclusively based on science (while, of course, it may use scientific information as an input). In that sense all decision rules are unscientific, including the rivals of the precautionary principle.

To sum up: these five common charges against the precautionary principle may, in various degrees, also be raised against competing decision rules. This is of course not necessarily an argument in favour of applying the precautionary principle. But it indicates that the critics of the precautionary principle might have to rethink their strategies. While the objections might sometimes be valid against some unreflected interpretations of the precautionary principle, they do not seem valid in principle. This should be

encouraging for proponents of the precautionary principle. But it should also urge them to refine their principle. We hope that they will not find the strategies outlined in this article completely unhelpful in this process.

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